DESTRUCTIVE INSECTS AFFECTING OHIO SHADE AND FOREST TREES

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OHIO AGRICULTURAL EXPERIMENT STATION

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CONTENTS

BULLETIN

OF THE

Ohio Agricultural Experiment Station

. NUMBER 332 NOVEMBER, 1918

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INTRODUCTION

The present publication is intended to supplant Bulletin 194, which appeared more than 10 years ago. Since the time of the previous publication, the investigational work pertaining to the control of insects affecting Ohio shade and forest trees has continued and has resulted in the accumulation of much information upon the subject, applying particularly to Ohio conditions. Moreover, public interest in the welfare of our trees has incerased tremendously during this period, which is evidenced by the serious thought that civic bodies, city administrations and great numbers of individuals are beginning to give to the matter.

In some measure, at least, this awakening may be attributed to the example set by the people of New England and eastern United States, who are annually spending hundreds of thousands of dollars in the care of their shade trees and who have demonstrated both from the purely financial as well as from the esthetic standpoint that the work is worth while. Nowhere is this brought out more clearly than in residential sections where the trees have been lost through neglect, resulting in tremendous decreases in property values and even in the abandonment of beautiful residences.

Note: The writer wishes to acknowledge his indebtedness to the following persons who in one way or another have assisted materially in the work attending the issuance of this bulletin.

Prof. H. A. Gossard has given generous counsel throughout the biological and economic studies which the bulletin embraces and Prof. Edmund Secrest has rendered valuable assistance, particularly in those sections of the work which lie quite as much in the field of arboriculture as they do in entomology, but which it seemed advisable to discuss briefly at this time.

The cities of Cleveland, Cincinnati, Marietta, Dayton, Canton and Ironton have cooperated generously, the first three having afforded facilities and inducements for the major portion of the investigational work. To various individuals in these cities the writer wishes to make especial mention. Messrs. M. H. Horvath, G. A. Rettig, John Boddy and H. C. Hyatt, City Foresters of Cleveland; Mr. C. R. Neillie, long in charge of the spraying work of that city; Messrs. William Hodgkinson and C. H. Meeds, Secretaries of the Board of Park Commissioners of Cincinnati and Messrs. J. W. Frye and W. E. Daker, Directors of Public Service of Marietta.

To Dr. L. O. Howard, Chief of the National Bureau of Entomology the writer wishes to express his appreciation for permission to use Plates XLIV and XLV and to Messrs. A. F. Burgess, L. H. Worthley and D. M. Rogers for courtesies extended from the Gipsy Moth Laboratory at Melrose Highlands, Massachusetts.

In antithesis to the foregoing condition, others have observed that the production of beautiful, uniform trees of desirable, lasting species will do more toward increasing property values and attracting buyers to a given section than will any other single item of improvement. There are many instances throughout the state where the promoters of subdivisions and additions to cities have given the matter of tree planting careful consideration—where the farsighted plan of using desirable species and allowing ample space for growth has been followed, regardless of the fact that such species may grow a little more slowly than some others and that the space allotted for trees may detract a few feet from the depth of the lots. Invariably the lots in subdivisions so planned and planted sell much more quickly and at higher prices than do those in equally desirable sections where tree conditions have not received proper attention.

Not all the increased interest in trees is confined to the towns and cities, since that of the rural districts has kept well apace. It is evidenced in the endeavors toward the beautification of country homes, in the care of the natural forest and woodlot, and most strikingly by the act of the General Assembly in 1915, when funds were appropriated for the purchase of a tract of land in Athens County consisting of 221½ acres, and of another in Lawrence County consisting of 1,500 acres to be used for forestry purposes.

Perhaps one of the most clearly outstanding reasons for this changing attitude is the fact that each year more of us are learning to appreciate a tree for its own sake, and the faster men and women acquire this viewpoint at just the same rate will lasting progress in civic and rural beautification be made. When we come to think of the trees on our premises in the same way that we think of our animal friends—as living organisms—unthrifty under abuse and responsive to attention, the trees of both city and country will take on an entirely different aspect. We do not pick up a puny cur from the alley and expect it to grow into a bench dog, nor do we select a blue blood and carelessly place it in the backyard, expecting it without any further attention on our part to develop into a perfect animal. Is it not just as reasonable to anticipate a magnificent tree from the stunted, misshapen specimen we dig up from the roadside or to expect even the finest, most thrifty, nursery-grown tree to cope with the many hardships of a city environment without any assistance on our part?

The smoke nuisance, cramped situations, mechanical injuries, careless mutilation either willful or accidental, gas and electrical injuries, and increased attacks from insect hordes, all are factors

with which the tree must cope when we take it from the environment of the "God-made country" and transplant it to that of the "man-made town." Perhaps no other single feature handicaps the tree so severely in its new location as does that of insect attacks, since insect injuries are much more common to city trees than to those growing in the country.

On the other hand, insect scourges occasionally develop over widespread urban districts, as, for instance, the outbreaks of the locust leaf beetle in southern Ohio, the oyster shell bark louse scourges of northern Ohio, and the caterpillar invasions of the last three years which swept the woodlands of the southern section of the State.

In view of the natural existing conditions, therefore, the present publication will in the main be of greater practical value to the city man, but it will fill the needs of the man in the country as well.

FACTORS ASSOCIATED WITH INSECT CONTROL IN CITIES

EFFECTIVE INSECT CONTROL DEPENDS ON THE SELECTION OF SUITABLE SPECIES OF TREES AND IN THEIR PROPER PLANTING

The problem of city insect control does not lie essentially in the field of pure entomology, thus concerning itself merely with the attempted annihilation of each individual pest as it appears, but in order to yield success it must be based upon a framework of ecological conditions reaching far into other branches of science. The present publication, in order to present a semblance of completeness, must therefore consider at least briefly some of these allied points.

The correct selection of species for planting; the first step toward insect control.—The control of insect pests begins with the very act of selecting the tree to be planted, indeed, with the spot to be occupied by the tree. A casual observer will notice that some trees are severely beset by insect pests while others are scarcely ever attacked; hence it is advisable to select non-susceptible species which at the same time combine with this feature natural beauty, longevity and rapidity of growth, as well as other desirable characteristics. How often does the one item, rapidity of growth, decide the species to be used and this accounts in large measure for the predominance of the Carolina poplar or cottonwood and the soft maple in many of the newer sections of our cities—both trees of little value for the permanent adornment of lawn or street.

Dr. E. P. Felt, in his most excellent memoir on "The Insects Affecting Park and Woodland Trees," has tabulated the more common trees of New York state with relation to their liability to

insect attack. As Ohio conditions are not vastly different from those found in New York state, Doctor Felt's rating in the main holds good here. With a few additions and alterations made on account of the variation in Ohio conditions as compared with New York, the rating is as follows: "The figure 3 has been placed opposite trees which are practically immune from insect injury; 2.5 indicates some damage. Trees having one somewhat serious enemy are rated at 2 and those having at least one notorious insect pest at 1.5. Greater likelihood of injuries is indicated by 1 and still more by .5." The species are arranged according to the comparative injury as follows:

Tree of heaven	3	Catalpa	2
Ginkgo	3	European linden	1.5
Red oak	2.5	American linden	1.5
Scarlet oak	2.5	Horse chestnut	1.5
Oriental plane	2.5	Buckeye	1.5
American plane	2.5	Soft or silver maple	1.5
Tulip, or tulip poplar	2.5	American elm	1.5
Sycamore maple	2	Hackberry	1.5
Sugar maple	2	Water or red elm	1.5
Norway maple	2	European elm	1
White pine	2	Scotch elm	1
Spruces	2	Cottonwood	.5
White oak	2	Carolina poplar	.5
Burr oak	2	Lombardy poplar	.5
Red maple	2	Balm of Gilead	.5
Honey locust	2	Yellow locust	.5

Let it not be understood that the writer intends the preceding list as the only guide to be consulted in the selection of trees for planting, since the character of the soil, amount of space available, scenic effects desired, as well as other points, should all be given due consideration. He does intend, however, that it may serve as a help in deciding what trees to use and what to avoid from the standpoint of insect control, other factors being equal.

Select healthy, vigorous trees for planting.—As intimated previously, the weakling of the lot, whether it be plant or animal, is usually the first to be beset by parasites; hence the selection of rugged, vigorous planting stock is another of the basic laws of shade-tree insect control. The transplanted, nursery-grown tree as a usual thing has a better-developed root system and form than the specimen taken from the woods, but care must be taken that the nursery-grown tree is not a stunted specimen from a lot of overgrown stock. Trees with withered, shrunken twigs or bark, with

blackened or badly dried roots, or those showing any symptoms of disease or insect attack should be discarded. To accept job lots of stock because it is cheap is never economy, for the first cost of the tree is one of the smallest items. In the production of a splendid tree, time is the greatest item of expense, and anything within reason to be done by way of securing the rapid development of desirable species is well worth while.

Plant to allow an opportunity for development.—Frequently the site of planting is such that tree growth is almost impossible. The soil may be unadapted to its needs because of chemical composition or physical condition or texture—indeed, in many instances trees are planted in such cramped situations that there actually does not exist a sufficient quantity of soil, regardless of its quality, for their development. Roughly speaking, the unhampered roots of a tree extend laterally as far as the branches; hence it is little wonder that trees fail to thrive when supplied with a narrow strip of surface earth from 1 to 2 feet in width, the remainder of the area being covered with sidewalk and paving. In many towns and cities in Ohio one can scarcely find a street where the area, between the sidewalk and paving, allotted to trees is more than 2 feet in width and, as might be expected, rarely is a beautiful tree to be seen in such places. In addition to the handicap of a narrow tree belt, the trees are frequently set too thick in the row. (Note for example Plate I, Fig. 1.) The wonder is not that the trees present a shaggy, sickly aspect, but that any trees exist to present any aspect at all.

On the other hand, well-selected stock planted in a tree belt of generous width will thrive under city conditions, and with care may surmount the difficulties attending a city environment. (See Plate I, Fig. 2.)

Avoid planting large areas to a single species.—Another factor which may be mentioned as being associated with that of insect control is the correct grouping or distribution of the various species of trees. The theory is supported by abundant available evidence that it is unwise to devote large areas to a single species, as is so frequently done. Occasionally, practically entire towns are found in Ohio which present almost a pure stand of a single species, and not infrequenfly are found entire sections so planted.

From the esthetic standpoint such uniformity is highly commendable but from the practical standpoint of insect control, it is to be avoided. The danger in planting large areas to a given species lies in the fact that most insects prefer certain food plants;

hence when a pest becomes established in the midst of a pure planting, it is afforded exceptional advantages for development and spread. As concrete evidence of the point, attention is called to Plate II, Fig. 1. As a further illustration of the fact, take for instance the case of Marietta, the most beautiful city in the State with respect to tree planting, where it is the writer's belief that nine-tenths of the trees are of a single species, the white or American elm. Some years ago, one of the elm scale insects, *Gossyparia spuria*, became established in the city, and at this time by reason of its having had an abundant, available food supply has become widely disseminated. Today the infestation bids fair to assume serious proportions unless diligent measures are taken to curtail it.

Planting of small units to a single species commendable.—While the writer is thoroughly opposed to the plan of devoting large areas to a single species, he is equally positive in his views that the planting of pure stands in smaller areas is desirable. Just where the dividing line should fall is difficult to say. It appeals to him as doubtful policy, however, to group more than a score or two of a given species, but in street planting several blocks or perhaps an entire street may be uniformly planted without involving any great danger. When the trees are in the extended planting of the street line, scourges among them do not spread nearly so rapidly as when they are grouped.

Some of the advantages of planting in units of the same species, especially in street work, may be enumerated as follows:

In street planting, formality is to be desired simply because any other scheme can hardly be employed to good effect, and it is rarely possible to secure this or uniformity either when trees of more than one species are used.

The unit planting scheme makes for uniformity and when the planting is of such a nature it is much more convenient to dispose of any electric or other wire lines which must be present with a minimum amount of injury to the trees.

The trimming of a uniformly planted street is much simplified, but one of the greatest advantages of all is the bearing it has on the work of spraying. When the trees are of a single species, they are much more likely to admit the use of a single spraying material and all may be treated at a given time. Moreover, when uniform in size, changes in the apparatus are not constantly necessary in order to adapt it to the treatment of trees of varying sizes. If the trees are of mixed sorts, one may require a given treatment; the next quite a different one, and a third no treatment at all. If small and

large trees are all mixed together, the one sort may be best sprayed with one type of nozzle or apparatus while the other may require an entirely different kind, and the time involved in the changing is both laborious and expensive.

Plant to make insect warfare possible.—Tall growing species subject to insect attack should not be planted in situations where the application of insect control measures is rendered difficult or impossible. For example, when trees are planted too close to buildings it is almost impossible to spray them properly without some of the mixture soiling the building. Those who have had experience will recall with regret the proceedings which usually follow after inadvertently covering the walls or windows of a house, especially if the work is being directed by public officials. The offense is sufficiently serious if a material is being used which readily washes off and leaves no permanent bad results; but it takes on the aspect of the unpardonable if the sulphur sprays, so frequently employed for scale control, are used, as these materials combine chemically with the paint of the walls, leaving them disfigured by ugly dark spatters and blotches.

CONTRIBUTING CAUSES TO DECREASED VITALITY OF TREES

Street trees require protection from mechanical injuries.—The chance for the city tree, particularly the one planted on the street, to receive mechanical injury is so great that means should be provided for its protection, especially during the earlier years of its life. The bark on the trunk and limbs of the young tree is very tender and when broken affords an excellent opportunity for the establishment of insect pests and fungous diseases. Such abrasions offer ideal entrance points for many of the boring insects.

These mechanical injuries may arise from several sources, the three most important of which are the biting of horses, thoughtless mutilation by passersby, and injuries by building operations and linemen.

Biting by horses.—With the increasing abundance of delivery automobiles and the corresponding decrease in the numbers of untied delivery horses, this menace to tree growth is rapidly becoming eliminated, but still remains a point of sufficient import to occupy our attention. After a wound is once started it is frequently kept open by having the healing edges gnawed until ultimately it may become a large, cankerous spot, not only unsightly and weakening to the tree but affording an ideal point of attack for boring insect pests. (See Plate III, Fig. 1.) Trees standing

within reach of horses should, by all means, be protected by some sort of metal shield. Many types are on the market, some of which are good and some so bad that they actually do more injury to the tree than it would receive were it left unguarded. It is not the ornate, gaudy protection that is most to be desired, but the unobtrusive sort which at the same time affords real protection to the tree trunk. If it is a tree that we want, then let us have a tree and not attempt its obscuration with a fancy-work mass of iron scrolls, bars and rods.

One of the most generally satisfactory types which the writer has observed is made from 15-inch galvanized hardware cloth, constructed of 16-gauge wire with half-inch meshes. The wire is cut into 6-foot lengths and made into a cylindrical form, either by hand or with the aid of a stove pipe or tinner's roller. At first the cylinder entirely surrounds the young tree, but as the trunk grows, the cylinder is opened and expanded to accommodate its growth. The points in favor of this protector are that it is simple, effective, inexpensive and very unobtrusive. Such a protector is shown in place in Plate III, Fig. 2, in the cylindrical form and expanded in Plate IV, Fig. 1.

Mutilation by passersby.—How frequently we find trees, especially newly-set ones, that have been mutilated either thoughtlessly or maliciously by passersby. When the bark is broken by a blow from a stick or a stone, or hacked with some sharp tool, the wound not only detracts from the sightliness of the tree but as with any other abrasion affords a point for insect pests or diseases to establish themselves. The protector just described is especially useful in shielding the tree from injury of this type, since the small apertures render it difficult to reach the bark.

Injuries by builders.—Still another important source of mechanical injury is that accompanying the careless disposition of materials during building operations. How frequently have we seen young trees ridden down, or the trunks of older ones badly bruised by the improper placing of such material. Where building is in progress the trees in the immediate vicinity should be well protected by rigidly constructed shields. (See Plate IV, Fig. 2.)

Overhead wires a menace to the health of trees.—Aside from the direct injury in the way of electric shock which so frequently occurs after the insulation has been worn away from charged wires passing through treetops, a more serious aspect of the situation is the butchery practiced by all types of aerial linemen in clearing out the treetops to make way for their wires. (See Plate V, Fig. 1.)

Very rarely are the first principles of correct pruning practiced and the tree is not only robbed of its natural and beautiful form but because of the mutilation is rendered particularly susceptible to parasitic attack. Many cities are eliminating this detracting factor from the welfare of their trees by passing legislation to put the wires underground or through the alleys.

Leaking gas mains a source of tree injury.—Another point which may be presented as associated with the problem of insect control in cities is the injury resulting from leaking gas lines. This is an important source of trouble, in many cases being responsible for the death of entire rows of trees. Attention is called to Plate V, Fig. 2, which shows such a row taken in the city of Akron during the summer of 1916. The previous year a gas line running near the trees rusted out, the trees suddenly wilted in midsummer, and were killed before the gas line could be repaired. Gas lines in the vicinity of the tree belt are a constant source of danger, and so far as possible should be eliminated from the streets of the residence sections. In many respects it would be far better practice to extend the lines down the alleys, and if this were the general custom, the danger of injuring trees would be greatly minimized.

CONTRIBUTING TO THE GENERAL VIGOR OF THE TREE AIDS IN INSECT CONTROL

Anything that can be done to contribute to the general vigor of the tree is an indirect help in controlling the pests which beset it. Many times trees would be able to withstand the ravages of insect attack were a little assistance given them in the maintenance of vitality by the furnishing of adequate moisture and plant food. With the area normally available to the tree but now greatly restricted by overlying pavement and sidewalk, the artificial supplying of these materials becomes quite essential. The most common method employed for watering is the insertion of the 3 or 4-inch tiles down into the root system and occasionally filling these with water. Sometimes commercial fertilizers are dissolved and introduced through the same channels, but in this process great care should be exercised lest the tree be injured by overapplication. A safer method is the working of manure or commercial fertilizer into the soil over the tree roots.

THE SCARCITY OF INSECT-EATING BIRDS IN CITIES PARTLY ACCOUNTABLE FOR THE PREVALENCE OF INSECTS

The final point to be considered of those most closely allied with insect-control problems under city conditions is the comparative

scarcity of insect-eating native birds. A census of the bird population of country and city shows a tremendous difference in favor of the former, with regard to both the number and the usefulness of the species involved. This condition is due, no doubt, in part to the lack of a natural habitat in the city and its environs, but partly due to thoughtless persecution. The latter, however, is rapidly decreasing from year to year, both on account of wise, firm legislation and on account of the changed attitude in the hearts of the people toward our natural friends. Unquestionably, the presence of the English sparrow in the cities has had a strong influence toward the practical elimination of our native insectivorous birds and the attending prevalence of the insect pests, since the sparrow is not a bird of pronounced insectivorous habits and, in addition, is notorious in its behavior toward other species. In justice, however, it must be said that there are some indications that the sparrow may be acquiring an appetite for insects, since the records of observed instances where this bird has actually captured and eaten insects are becoming increasingly abundant from year to year.

Efforts to attract the native birds and win them back to the city by offering food and shelter are well worthy of consideration. Certainly such efforts will be repaid manyfold in the currency of countless insects destroyed and at the same time will yield a harvest of pleasure not previously imagined.

INSECT CONTROL POSSIBLE UNDER CITY CONDITIONS

With but a few exceptions, the control of injurious insect pests under city conditions is possible and at the same time highly practicable. The tree growing in the city, especially in the residence and park or boulevard districts, is valued far above the actual worth of the lumber contained, by reason of its influence on nearby property values, and hence its protection from the work of its natural enemies is a matter of business economy. This, of course, involves the expenditure of funds, in many cases in insignificant amounts as compared with the returns secured. In other instances the outlay may be considerable but still not prohibitive when the real value of the tree is taken into consideration. The element of time is the greatest factor involved in the production of a good tree. The expenditure of a few dollars at a critical period may be the means of saving a splendid specimen, which might require a century to replace.

In a very few instances, however, particularly with outbreaks of some of the boring insects, the successful execution of control measures is quite impossible.

INTENSIVE CONTROL MEASURES RARELY POSSIBLE UNDER FOREST OR WOODLOT CONDITIONS

While the execution of measures for the control of noxious insect pests infesting city trees is highly practicable and to a somewhat less degree in the care of shade and ornamentals in the country, the exact reverse is true when we consider the artificial control of insect scourges in the average Ohio woodlot or timber tract. Timber values at present do not justify the expense involved in the enterprise. As an example of the latter condition, the recent scourge of oyster shell bark louse in the ash woodlots of Geauga and Ashtabula Counties may be cited. A few years ago this insect obtained a firm foothold on ash in the northeastern section of the State and was especially prevalent in the two counties named. Hundreds of magnificent trees were killed outright and much cutting was done on account of the trees being severely infested, which otherwise would have been delayed a number of years. It was entirely impracticable to spray (see Plate VI, Fig. 1) on account of the size of the trees and the expense of adequate machinery and the necessary materials the work would have required; hence nothing was to be done but let the scourge take its course. Fortunately, the crest of the attack passed after two or three seasons of severe injury and the natural enemies overtook the scale and subdued it, but not until injury amounting to many thousands of dollars had been done.

On the other hand, the control of insect scourges in woodlands is sometimes practicable, as demonstrated in some sections of New England, where annual spraying is practiced for the control of the gipsy and brown tail moths. Where the work is well organized and the proper equipment is at hand, not only can insect outbreaks be controlled under such conditions but the expense of the procedure is much less than one might suppose. (See Plate XIII, Fig. 2.) Under New England conditions both the material and the esthetic values of the woodlands are combined to make the enterprise practicable, but as matters stand at present in Ohio, the sprayng of woodlands is not practicable, especially in those sections of the State where land values are extremely low.

ESTABLISHING A MUNICIPAL TREE-TREATING DEPARTMENT

INSECT CONTROL IN CITIES A MUNICIPAL PROBLEM

The application of insecticidal measures is a difficult task under most city conditions, especially if the various householders attempt the operation individually. It is usually the case that a few trees

only are located in each yard or along the street bordering it, and frequently these trees are tall; thus in the matter of spraying, not only is a strong, expensive apparatus necessary for doing the work properly, but in addition, the services of at least two men are required. One of these men should have a proper knowledge of spraying materials and of their application, and in this day, when labor is scarcely to be had at any price, the securing of specially trained labor is quite beyond consideration. It is only in instances where individuals have large lawns and employ regular labor that the operation of private spraying rigs becomes practicable.

In controlling a few of the shade tree pests, however, as will be seen from a study of their life histories and habits, the individual householders may render very pronounced assistance with no great expenditure of either time or money.

Taking the problem as a whole, after a number of years of observation, the writer is firmly convinced that the matter of insect control in cities and towns is not one of individual endeavor, but that it justly belongs to the municipality. The matter of fighting the noxious insect pests of a city should be considered in the same light as that of fighting her fires, since the two have many points in common. Long since have we passed the way of thinking that each man should be responsible for the control of fires on his premises or that the pioneer development of the bucket brigade or civilian hose company was adequate for the purpose. Now we take pride in our highly-perfected equipment and our specially trained corps of men to handle it. With respect to the control of noxious insect pests, however, in most cities of the State the matter has not even reached the bucket brigade stage.

While the problems of insect control and fire control have many points in common, in one respect at least, they are highly dissimilar. A building may burn and within a year may be replaced by another even greater and better, simply through the expenditure of a few thousands of dollars, whereas if a magnificent tree is lost, no amount of money can replace it immediately, but a century of time and attention may be required to produce another to equal it in size and beauty.

PROPER LEGISLATION THE FIRST STEP NECESSARY

In order to afford a basis for the foundation of a department of municipal insect control, the first essential is the enactment of legislation to authorize and regulate its activities. The city of Cleveland after about 10 years' experience with ordinances of this

kind recently has adopted a new one formulated upon past experience. The new ordinance is given verbatim in the following paragraphs.

AN ORDINANCE PROVIDING FOR THE MANAGEMENT, PROTECTION AND CONTROL OF STREET TREES IN THE CITY OF CLEVELAND, OHIO

An ordinance to supplement Chapter 22 (XXII) of the revised ordinance of the city of Cleveland, of 1907, and to repeal ordinance No. 10396-A, passed February 10, 1908, ordinance No. 16459, passed November 29, 1909, and ordinance No. 21089, passed September 25, 1911.

BE IT ORDAINED BY THE COUNCIL OF THE CITY OF CLEVELAND, STATE OF OHIO:

Sec. 1. That Chapter 22 of the revised ordinances of the city of Cleveland, be supplemented by adding thereto the following supplemental heading and sections.

MANAGEMENT, PROTECTION, CONTROL OF STREET TREES

Sec. 2. **Unlawful to cut, break, climb or injure tree or plant. Injure, misuse or remove device.**—It shall be unlawful for any person, firm or corporation without a written permit from the Director of Parks and Public Property to cut, break, climb or injure any tree or portion of tree planted or growing in any public highway within the city of Cleveland or cause, authorize or procure any person to cut, break, climb or injure any such tree or portion thereof; to cut, break, climb, or injure any tree or plant, or to injure, misuse or remove, or cause, authorize or procure any person to injure, misuse or remove any device set for the protection of any tree or plant in any public highway of said city.

Permit to cut, trim or prune necessary.—Any person, firm or corporation desiring for any lawful purpose to cut, prune, treat, with a view to its preservation from disease or insect, or trim any tree in any public highway of said city, may apply to the Director of Parks and Public Property, and if in the judgment of said Director the desired cutting, pruning, treatment or trimming shall appear necessary, and the proposed method and workmanship thereof such as said Director approves, the Director may thereupon issue a written permit for such work. Any work done under such written permit must be performed in strict accordance with the terms thereof.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section or of any permission given as aforesaid shall, upon conviction thereof, forfeit and pay a penalty of not to exceed five dollars ($5.00) for each and every such offense.

Sec. 3. **Kill or remove tree or plant.**—It shall be unlawful for any person, firm or corporation to kill or remove, or cause, authorize or procure the death or removal of, any tree planted or growing in any public highway within the said city of Cleveland. Any person, firm or corporation desiring for any lawful purpose to take down or remove any tree in any public highway of said city of Cleveland may apply to the Director of Parks and Public Property and if in the judgment of the said Director, the desired taking down or removal shall appear necessary, the Director may thereupon issue a written permit therefor. Any work done under such written permit must be performed in strict accordance with the terms thereof.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed fifty dollars ($50.00) for each and every offense.

Sec. 4. **Gas, etc. as may injure.**—It shall be unlawful for any person, firm or corporation owning or using, or having control or charge of gas or other substance deleterious to tree life, to allow such gas or other substance to come

into contact with the soil surrounding the roots of any tree in any public highway in the city of Cleveland in such manner as may injure such tree or plant.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed ten dollars ($10.00) for each and every such offense.

Sec. 5. **Gas, etc. as shall kill.**—It shall be unlawful for any person, firm or corporation owning or using, or having control or charge of gas or other substance deleterious to tree life, to allow such gas or other substance to come into contact with the soil surrounding the roots of any tree in any public highway in the city of Cleveland in such manner as shall kill or destroy such tree or plant.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed fifty dollars ($50.00) for each and every offense.

Sec. 6. **Brine water, oil, etc., and other substance.**—It shall be unlawful for any person, firm or corporation to cause, authorize or procure any brine water, oil, liquid dye or other substance deleterious to tree life to lie, leak, pour, flow or drip on or into the soil about the base of the tree in any public highway in the city of Cleveland, or onto the sidewalk, road or pavement therein at a point whence such substance may by lying on, or by flowing, dripping or seeping into such soil, or in any other manner whatever, injure such tree; or to cause or procure such lying, leaking, flowing, dripping, seeping or injuring.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed five dollars ($5.00) for each and every such offense.

Sec. 7. **Stone, cement, etc.**—It shall be unlawful for any person, firm or corporation, except with the written permit of the Director of Parks and Public Property, to place or maintain upon the ground in any public highway within the city of Cleveland, any stone, cement or other material or substance in such manner as may obstruct the free access of air and water to the roots of any tree or ornamental plant in such highway.

Minimum opening.—Unless otherwise provided for in such written permit as above provided for, there must be maintained about the base of the trunk of each shade tree in the public highways of the city at least 6 square feet of open ground for a tree 3 inches in diameter, and for every 2 inches of increase of such diameter there must be an increase of at least 1 square foot of open ground.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure the violation of any provision of this section, shall upon conviction thereof, forfeit and pay a penalty of not to exceed ten dollars ($10.00) for each and every such offense.

Sec. 8. **Power to preserve or remove trees.**—The Director of Parks and Public Property shall have the right to plant, trim, preserve and remove all trees within the lines of all streets, alleys, avenues, lands, lanes, squares and public grounds as may be necessary to insure safety, or to preserve the symmetry and beauty of such public grounds. The Director of Parks and Public Property, under the power here given, may cause any tree which is in an unsafe condition, or which by reason of its nature is injurious to sewers or other improvements, or is affected by any injurious scale or other pest to be removed.

Sec. 9. **Interference, Park Director, employes, etc.**—It shall be unlawful for any person, firm or corporation to interfere or cause or authorize or procure any interference with the Director of Parks and Public Property, or any of his employes, agents, or servants, while they are engaged in and about the planting, cultivating, mulching, pruning, spraying or removing of any tree in any public highway within the said city, or in removing any device attached to said tree or in such removing of stone, cement, sidewalk or other material or substance as may be necessary for the protection and care of any such tree

in accordance with the requirements set forth in Section 7 hereof as to the area of open ground to be maintained about the base of the trunk of each shade tree in the public highways of the city.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section, shall upon conviction thereof, forfeit and pay a penalty of not to exceed ten dollars ($10.00) for each and every such offense.

Sec. 10. **Injury by wire or electricity.**—It shall be unlawful for any person, firm or corporation to cause, authorize or procure a wire or other conductor, charged with electricity, to come into contact with any tree in a public highway in the city of Cleveland in such manner as may injure or abrade such tree or plant.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed five dollars ($5.00) for each and every such offense.

Sec. 11. **Killing by wire, or electricity.**—It shall be unlawful for any person, firm or corporation to cause or authorize or procure a wire or other conductor charged with electricity, to come into contact with any tree in any public highway in the city of Cleveland in such manner as shall destroy or kill such tree or plant.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed fifty dollars ($50.00) for each and every offense.

Sec. 12. **Attaching wire, rope or sign.**—It shall be unlawful for any person, firm or corporation to attach or keep attached to any tree in any public highway in the city of Cleveland, or to the guard or stake intended for the protection of such tree, any rope, wire, sign or any other device whatsoever, except for the purpose of protecting it or the public.

Peanlty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed five dollars ($5.00) for each and every such offense.

Sec. 13. **Horse injury or possible injury.**—It shall be unlawful for any person, firm or corporation to tie any horse or any other animal to any tree in any public highway within said city of Cleveland, or having charge of such horse, or other animal, to allow or cause or procure it to injure any such tree; or for any person in charge of such horse or other animal to cause or allow it to stand so that it can injure such tree.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed ten dollars ($10.00) for each and every such offense.

Sec. 14. **Permit to plant necessary.**—It shall be unlawful for any person, firm or corporation to plant or set out any shade tree or cause or authorize or procure any person to plant or set out any shade tree, in or on any part of any public highway within the city of Cleveland without first obtaining from the Director of Parks and Public Property a written permit to do so or without complying in all respects with the conditions set forth in such written permit.

Before any permit shall be issued for planting more than twenty-five trees on any one permit, the Director may request from the applicant a detailed declaration of intentions either in the form of a planting plan or written statement in duplicate. All planting plans shall be drawn on tracing cloth in ink. One copy of each plan or statement of intentions shall, when approved by the Director, be returned to the applicant and the other copy shall be kept on file by the Director.

All planting plans shall show accurately:

(a) The proposed street width, together with its subdivisions of pavement, curb, gutter, parking strip and sidewalk areas, to a definite indicated scale.

(b) The proposed location of each and every proposed tree together with the location of each existing within the proposed street lines in scaled relation to the other features of the plan.

(c) The variety of each and every tree proposed to be planted and of those already existing within the proposed street lines, either indicated on the plan or referenced with a number to key list.

(d) The distance between trees in any one row in feet.

(e) The nature of the soil in the planting space, to a depth of three feet, and all existing and proposed surface or subsoil drainage systems.

All statements filed in lieu of a planting plan shall contain the same information as required on a plan.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed five dollars ($5.00) for each and every such offense.

Sec. 15. **Guard trees while building.**—During the erection, repair, alteration or removal of any building or structure within the city of Cleveland, it shall be unlawful for the person or persons in charge of such erection, repair, alteration or removal, to leave any street tree in the vicinity of such building or structure without such good and sufficient guards or protectors as shall prevent injury to said tree arising out of or by reason of said erection, repair, alteration or removal.

Penalty.—Any person, firm or corporation which shall violate or authorize or procure a violation of any provision of this section shall, upon conviction thereof, forfeit and pay a penalty of not to exceed ten dollars $(10.00) for each and every such offense.

Sec. 16. **Power to preserve or remove tree or shrub located on private ground.**—The Director of Parks and Public Property shall have power to enter upon any private grounds in the city of Cleveland and to cause to be sprayed or otherwise treated any tree or shrub infected or infested by any parasite or insect pest when it shall be necessary in the opinion of said Director to do so, to prevent the breeding or scattering of any parasite or animal pest, and to prevent danger therefrom to shade trees and shrubbery planted in the streets, alleys and public grounds of the city of Cleveland, and whenever in the opinion of said Director, trimming, treatment or removal of any such tree or shrub located on private grounds shall be deemed wise, the said Director shall have power to trim, treat, or remove any such tree or shrub.

Sec. 17. **Continued violation.**—Every violation by the same person, firm or corporation, of any provision of any section of this ordinance, which continues on any day or days succeeding the first violation thereof, shall constitute an additional violation for each of such succeeding days.

Sec. 18. That ordinance No. 10396-A, passed February 10, 1908, ordinance No. 16359, passed November 29, 1909, and ordinance No. 21089, passed September 25, 1911, be and the same are hereby repealed.

Sec. 19. This ordinance shall take effect from and after the earliest period allowed by law.

ORGANIZATION OF THE DEPARTMENT

Various schemes are in operation for the organization of the municipal tree-treating department, but the two which seem most popular in eastern United States, where more attention is given the matter than in any other section of the country, may be classified as the commission plan and the city department plan. Of the two, the former as a rule is most satisfactory.

The commission plan.—With the commission plan the authority is centralized in a commission of three members or more, usually nonpartisan and nonsalaried. As a rule, the personnel of the com-

mission is composed of public-spirited business men who stand high in their community and who are willing to donate some of their time and thought to the cause of the public good.

An executive officer is appointed by the commission whose duty lies in putting into operation the ideas of the commission. This officer may be called the secretary of the commission, the entomologist, the forester, or by some other name, but regardless of his title he should be well versed in all matters concerning trees and should be consulted freely by the commission members, especially on all points of a more or less technical nature, since the commissioners themselves are not necessarily supposed to be thoroughly informed regarding such details.

Working directly under this executive officer and responsible to him alone, may be specialists or foremen in charge of the various departments of the work and under the foremen the laborers.

The size of the organization, of course, depends upon the magnitude of its duties, but great care should be exercised in preventing over-organization, since the over-organized department results in an overhead expense wholly disproportionate to other items. At the same time, however, while the danger of over-organization is a great one, an equally grave possibility of under-organization exists, the latter condition being just as likely to hamper the successful execution of the work. One man cannot give the proper attention to all the operating details of such a department, though it be one of no more than moderate size.

The city department plan.—With the city department plan of organization the work may be conducted upon the same basis as that of any other city department, and the leader of the work may be classed on a par with any other departmental head, such as the chief of police, chief of the fire department, etc. In some cities the work of looking after the tree problems is made a phase of the work of some other department, as for instance a branch of the Public Service Department. In the larger cities of the State, if the plan is followed of conducting the work under the city department plan rather than by the commission plan, the department should be one of full standing with other city departments; but in the smaller cities, where the expense of maintaining a separate organization is not justified, it is best made subsidiary to some department already in existence.

A civil service basis desirable.—After an investigation of the shade-tree problem over a 10-year period in Ohio and an extended trip of inspection of some of the existing departments in the New

England States in 1914, the writer has become convinced that the only thoroughly successful method to operate such a department is along broad civil service lines. The personnel of the force should be selected on a civil service basis; that is, the men who are best equipped to do the work should be given the positions and after the positions are filled, continuity of service should be maintained in so far as possible. It has been his observation that the most successful departments are those in which these principles are adhered to, from the position of general director on down the scale to the workmen. By such a plan certain men become proficient along certain lines and hence are thus far more efficient than inexperienced men can ever be. In the matter of spraying alone, the constant changing of workmen results in tremendous losses of materials during the process of educating the newcomers. One city department which the writer has in mind has had a new force of workmen to handle the spraying rigs almost every season and some seasons has had two groups to train.

The most striking difference between the commission plan of organizing the department and the city department plan lies in the fact that the former makes for the application of civil service principles and the latter operates against it. The city department is constantly subject to turmoil and upheavals becauses of changing political administrations, and the personnel of the department in many cases is selected and maintained largely through political preference. Many times has the writer seen efficient, conscientious men replaced by rounders and henchmen whose only interest in the work was the periodical advent of the pay car and its quota of yellow envelopes—men whose only qualification for the work to be done was that the "man higher up" demanded that they be accommodated with a berth.

Because of the role he thus plays in contributing to the delinquency of his city's trees, this "man higher up," if he is an unscrupulous politician, may justly be termed a pest of first quality who well deserves a place in the insect rogues' gallery. He should be given equal prominence with *Aspidiotus perniciosus*, *Hemerocampa leucostigma* and *Thryidopteryx ephemeraeformis*; indeed, even greater prominence, for the entomologist showers such pests with noxious chemicals or even poisons their provender and is cheered for his efforts, whereas the same treatment meted out to the politicians would speedily bring him into conflict with the law and perhaps consign him to the gallows.

SCOPE OF WORK

The municipal tree department in order to be most useful should have entire charge of the trees growing upon the land owned and controlled by the municipality, and should have power to enter private property for controlling outbreaks of noxious pests. Moreover some provision should be made whereby the department may respond to appeals from private individuals desiring assistance in caring for trees already planted or in laying out grounds and planting new trees.

If the work concerning the trees is divided between two organizations or more, certain phases of it are certain to overlap and still others to be neglected. Moreover, the tree activities should be centralized, for in this way employment can more likely be furnished during the entire year for the men. If the work is so organized that it becomes necessary to dismiss most of the force during certain seasons, the men find employment elsewhere during their idle months and naturally are unwilling to return to a sporadic position when the season for work opens. Such a plan operates toward its own defeat, since, as already shown, continuity of service is one of the prime essentials for the success of the work.

If all the items concerning the care of the trees and shrubs of a city are centralized in one department, it automatically follows that at least the greater number of the men can be employed during the entire season. In fact, it is a good plan for those in charge to have the opportunity to do some pruning on the force at certain seasons, since they are thus afforded the chance to eliminate the shirks.

It is also good policy to put into operation a variable wage scale by which the men receive more for the busy seasons of the year and less when work is slack, since such a plan has a tendency to hold the men for the times when they are most needed, as, for instance, the spring and summer spraying seasons.

Briefly discussed, the more important divisions of the physical work of a municipal tree department are as follows: Growing the planting stock, planting, protecting, pruning, cultivating, watering, fertilizing, mowing, spraying, etc.

With such a range of work to do, and with a little foresight in management, employment can be furnished for the men during nearly the entire season. The time when it is most difficult to find employment for the force is, of course, during the three winter months, but if working quarters are available the time can be spent

to fair advantage in overhauling machinery, making tree stakes and tree guards, preparing cuttings, working in forcing houses, and the like.

In addition to the outside, or so-termed physical work of such a department, an adequate office force must be maintained for the preservation of records. In some of the eastern cities these records are so complete that each tree is listed and a complete account kept of all the work done upon it. Where the system of keeping the records is not too complex, the work is well worth while, since the data thus accumulated are found to be exceptionally valuable.

Such an office is quite indispensable in cities where shade tree work is being done, as a center for disseminating information regarding tree matters, and for receiving requests, reports and complaints concerning them.

COST OF MAINTENANCE

Figures pertaining to the cost of operation and maintenance of the tree activities in the various cities of the land where such work is being done are difficult to obtain, since the funds for the work are in many cases combined with those of other departments. Moreover, where such data are available, there seems little basis for comparison on account of the diversity of conditions which exist and the variation in the character of the service performed. In the New England cities, where the leopard, gipsy and brown-tail moths and the elm-leaf beetle are present, the expense of maintaining such a department is of course greatly increased. Then, again, the amount of work done also has a vital bearing upon the item of expense since the cost of caring for a city's trees in the best possible way is much greater than if only one or two items of their care receive attention, such as spraying and pruning.

It might be of some benefit, however, to refer briefly to the data concerning the work of the Newark (N. J.) Shade Tree Commission. Attention is called to Newark, first, because of the abundance of essential data which are available and, second, because the work of this commission executed by its able secretary, Carl Bannwart, stands exceptionally high in the opinion of those versed in such matters, since it handles, not one or two, but all phases of the shade-tree problem in a most thorough and capable manner.

Approximately sixty thousand trees were growing on the thoroughfares of Newark in 1912, according to the commissioner's report, and the total expenditures of the commission for that year for both street and park work were slightly more than $64,000 or,

in other words, about a dollar per tree annually, including all items, such as new plantings, spraying, trimming, protecting, cultivating, watering, etc. At the same time more than $10,000 of the sum named was expended for permanent improvements in parks, for maintenance of comfort stations, and for other items closely associated.

TREE DOCTORS, QUACKS, ETC.

Today when we are almost without laws regulating the practice of tree surgery, public spraying and the like, the public is at the mercy of the practitioner. Calling himself an expert and using a few high-sounding terms with which his glib tongue paints a masterpiece of the woe and destruction sure to ensue if his services are not accepted forthwith, he holds the average householder at his mercy. The so-called expert can charge any price per hour and work as many hours as he cares and the householder pays the bill. The highly-groomed trees sometimes seen aptly remind one of the equally over-groomed town dandy. Moreover, it is likely that the pampering, particularly the practice of removing all the rough bark from the trunk, is equally as unprofitable as the time spent by the dude in primping. Further, the removing of the rough bark may cause positive harm to the tree.

Still another class of tree practitioners abound who promote and apply the use of fake remedies, as, for example, the man who sells a concoction that he says is effective against all forms and types of insect pests. Like cure-all patent medicines such nostrums and their promoters should be avoided.

From the foregoing remarks, however, the writer does not wish to imply that all present-day tree surgeons are bad, nor to reflect in the least upon the work of the reliable ones, for he has come in close contact with some men who were performing high-grade, conscientious service. Such legislation as that proposed, tending to limit the practice of their profession, would prove a boon rather than a hardship to such men.

SPRAYING MACHINERY AND ACCESSORIES

Tremendous progress in the development of spraying machinery has been made, particularly during the last decade. One of the more important phases of this outgrowth has been the production of special types to serve the requirements of different classes of work to be done; this has not only resulted in increased efficiency in the use intended but at the same time has made necessary the

careful study of the different types, by intending purchasers, in order that a machine adapted to their needs might be selected.

The spraying machines of the present day may conveniently be divided into two classes—the so-called mist, or fog, sprayers and the solid-stream sprayers.

SPRAYING MACHINES OF THE MIST, OR FOG, CLASS

As the name implies, mist sprayers are so constructed and equipped that the spraying material is delivered in the form of a mist, or fog. The height of efficiency is the delivery of the liquid broken up in the finest particles possible, in the most uniform manner and in quantities commensurate with the demands at hand. The field of usefulness of this type of sprayer for a number of reasons is more general than is that of the solid-stream sprayers. The more important of these reasons is that in general spraying operations the plants to be sprayed are not extremely high and under such conditions it is much easier to apply the foglike spray evenly and economically. Issuing as it does in the form of a mist, or fog, it settles on the object under treatment and remains in position. In the spraying of high trees, however, this feature becomes a serious handicap since the mist spray carries but short distances and in order to cover the higher parts of the tree, ladders and climbing must be resorted to. This process becomes a serious handicap in a number of ways. It makes the work exceedingly slow and tedious and by so doing adds greatly to the expense. Moreover, it is difficult for the nozzleman to spray the tree perfectly when clambering through the top. On account of the mechanics involved, a spray of the mist, or fog, type is much easier produced than the solid stream type, the latter requiring from 150 to 200 pounds additional pressure in order to work most satisfactorily.

The principles involved in the construction and the essentials to be borne in mind in the equipment of the mist sprayers are so completely discussed in two previous publications from this Station (1 and 2)* that these phases will be dealt with but briefly at present, and the remarks to be made will be largely of a supplementary nature in order to discuss a few points which apply particularly to the selection and equipment of machines for use in shade-tree spraying. Intending purchasers of spraying machinery who are not well versed in the mechanics involved as well as in the status of development of the modern spraying machine should not attempt to make their selections without consulting these two publications.

*These numbers and those which follow refer to the list of references, the beginning of which will be found on page 473.

Hand-driven mist sprayers.—The earlier machines used for spraying in park and shade-tree work were, of course, the hand-driven types, such as the examples shown in Plate VII, Figs. 1 and 2, but long ago the hand-driven pumps were relegated in favor of the power-driven ones. For many reasons the field of usefulness of the former is greatly restricted and rarely today can they be employed to advantage, except perhaps in the spraying of shrubs, in nursery work or in treating small trees not easily accessible to the power sprayer. Experience has taught that the saving made by the lower original cost of the smaller machine is quickly obscured by the greater cost of operation in applying the large quantities of spraying material required in the treatment of large trees. Thus the superiority of the power-driven machine for the purpose at hand has been fully demonstrated, not only with regard to the cost of the operation but in the efficiency of the work as well, and it scarcely seems worth while to devote further space to the discussion of the hand types.

The power-driven mist sprayers.—Only the larger, better-built power sprayers survive the usage and hardships to which the city spraying machine is subjected; hence the greatest of care should be exercised in selecting the make and type to be used. Capacity, simplicity, durability and a suitable equipment of accessories, as pointed out in the publications previously referred to (Buls. 216 and 248, Ohio Agr. Exp. Sta.) are all highly essential general features which the machine should embody.

In detail, the specifications of a modern power mist sprayer best suited for general city spraying may be given as follows:

Pump.—Capacity 8 to 10 gallons per minute at a pressure of 200 pounds per square inch; equipped with pressure gauge; adjustable automatic pressure regulator; spacious air chamber to insure constant pressure; complete oiling system; construction such that the parts, especially the valves, are easily accessible and with a complete system of drainage to prevent freezing.

Power.—Gasoline engine of sufficient rating to deliver with ease the power required; preferably four-cycle upright type; and equipped with high-grade carbureter, magneto and dependable oiling system.

Tank.—The capacity of the tank should not be less than 200 gallons and 300 is usually perferable for city work. Provision should be made for washing and draining.

Housing.—For city work, the pump and engine should be housed in order to avoid soiling by the spray. The housing should be so constructed that the sides can be locked down in order to protect the machine from depredations when idle on the streets.

Agitator.—The rotary type of agitator is generally considered best. The construction should be such that it can be disconnected from its motive power, during certain operations.*

*In using the soluble or miscible oils, it is advisable to disconnect the agitator after the solution is thoroughly mixed, since long continued agitation is likely to impair the emulsion, a spongy mass resulting which resembles freshly churned butter.

Hose.—The best grade of spray hose obtainable should be used and is most satisfactory if divided into 100-foot lengths. Three hundred feet is adequate for street work, but where park spraying is done, especially if the land is very uneven, 500 or 600 feet should be provided. If no more than 300 feet is in use, the hose may be of the half-inch size, but where greater lengths are employed, at least the first 200 feet, that is, the section nearest the machine, should be three-fourths to 1 inch and the remainder may be of the smaller caliber. Under some conditions it is possible to run two lines of hose to advantage, but as a usual thing, particularly in street work, one line is found to be best, two or more large capacity nozzles being employed to expedite the work. Particular care should be given the type of hose connections used, since the dragging about of the long lines subjects the hose to a tremendous strain, and unless the connections between the sections are especially well constructed they are pulled out. Supplementary sections of hose should be carried with the machine so that in case a section breaks in use, or the connections pull out, another unit may be supplied and the defective one repaired at leisure.

Extension rods.—Brass-lined, bamboo extension rods, 10 to 12 feet in length and equipped with drip guard and leakless cut-off should be used. At least one and preferably two extra rods should be carried with the machine.

Nozzles.—Nozzles of the large disc type, at least two to the extension pole and set at an angle of about 30° are best. Several extra nozzles should be carried.

Tool box.—While seemingly a minor item, a spacious tool box, well filled with tools and extra supplies, is especially desirable in city spraying. Not infrequently the machine is used several miles from its base of operation and in the absence of a generous set of tools, a repair of insignificant importance may delay the work several hours while a trip is being made for the necessary implements or supplies.

Truck.—The truck should be well constructed; equipped with wooden wheels, high-grade springs and a brake. These three specifications are each of especially great importance. Iron or steel wheels rarely will survive the unevenness of the average city pavement. Wide-tired, heavily constructed wooden wheels with many spokes, seem the only type that will give satisfaction. The springs are necessary since without them long hauls over rough pavement usually jar loose some part of the machine and may thus cause no end of inconvenience and delay.

The loaded city sprayer usually weighs from 3 to 4 tons; thus a brake is essential to the safety of operation.

The final specification concerning the truck is that it should be of the cut-under type to facilitate turning. Attention is called to Plate VIII, Fig. 1, which shows a well-constructed and equipped sprayer of the mist type. The machine illustrated is owned and used by the Board of Park Commissioners of the city of Cincinnati.

Operating a municipal mist sprayer.—During the period of about 10 years that the writer has spent in the study of the shade and forest insect problem in Ohio, he has had the opportunity of observing and of doing a considerable amount of actual spraying under city conditions. From this experience he has learned that operating a sprayer in the city and in the country are two entirely different affairs. For instance, and especially in street work, no matter what the capacity of the machine, more than one line of hose can rarely be used. The constant passing of vehicles makes it impracticable to operate upon both sides of the street at once, and if two men try to spray on the same side, they are constantly interfering with one another. In order to facilitate the work, there-

fore, more nozzles should be used on a single line and a lively workman should direct the nozzle. It is also advisable to have at least one and sometimes two men to serve as hose bearers, especially if extra lengths of hose are being employed. One man should be with the sprayer constantly to keep the machinery in good order and to drive the team. Another man, well versed in the work of spraying and the reasons therefor should accompany the rig to answer inquiries, guard pedestrians or vehicles from passing beneath dripping trees or through the drift of the spray. Without such a man along to explain the work, the entire outfit is being stopped constantly by persons who wish to know why the work is being done, if it is going to cost them anything, and the like. If the sprayer is not arranged for carrying the unmixed sprays, extra hose, etc., a light attendant wagon should accompany the rig to have the stock supply of spraying materials readily available. Of course, arrangements should be made for taking the water for mixing the sprays from the city mains. The fire plugs are most convenient for this purpose.

In operating city sprayers, it has frequently come to the attention of the writer that one of the misplaced economies in the work is too rigidly docking the workmen for "layoffs" on account of bad weather. Since spraying cannot be done after a rain while the trees are still wet, or during rainy weather, considerable time is lost while other workmen are losing but little; hence it is difficult to keep the gangs satisfied. To remedy this evil, leniency in docking should be exercised by timekeepers and foremen for time so lost.

THE SOLID-STREAM SPRAYERS

Description.—The solid-stream sprayers, as the name implies, are so constructed and equipped that they deliver the spray in a solid or unbroken stream until it reaches its maximum height, when it suddenly explodes or separates into a fine mist. This result is obtained by forcing the spraying liquid at tremendous pressure through an exceedingly smooth-bore nozzle having an aperture varying in diameter from one-eighth to five-sixteenth of an inch. The height attained by the stream before exploding varies in accordance with the size of the nozzle aperture and with the pressure employed. With the pressure remaining constant, the larger the aperture the higher the spray may be thrown. By using the five-sixteenth inch aperture with a pressure of 225 pounds at the nozzle, it is possible to throw the spraying material 90 to 100 feet in the air and with this equipment and pressure to deliver approximately 25 to 35 gallons per minute. The operator is able to remain on the ground and reach the tops of most trees; and this fact, together with the

large capacity of the machine, contributes greatly toward facilitating the work and reducing its cost. (See Plates IX, X, XI, XII and XIII.) In spraying with the solid-stream type, it is much easier to operate against adverse wind currents both with regard to placing the spraying material where desired and in preventing its soiling nearby buildings. Those who have had experience in city spraying will recall the inconvenience caused by the variable winds of the streets. (See Plate X, Fig. 1.)

The solid-stream sprayers are of course of comparatively recent development, and thus have not approached the point of standardization reached by the mist types; hence it is impossible to set forth in such complete detail the specifications of a solid-stream spraying outfit as has been done with the mist machine. Such an attempt would merely result in giving the specifications of each of the several machines on the market which claim the right to the title of solid-stream sprayers.

In general, however, the solid-stream machines are heavier and stronger in every way. The engine is rarely less than 10 horsepower; the pump of the multiple cylinder type; the tank of 400 or 500 gallons capacity; the truck stronger and more durable; and the hose larger in diameter.

The increased strength and size are made necessary because of the increased capacity and pressures required in this kind of work. In addition the workmanship must be of the highest quality. When a machine is operated under 350 to 400 pounds pressure at the pump in order to insure 250 pounds pressure by the time the spraying material reaches the nozzle, every item of its makeup must be well-nigh perfect in both workmanship and repair.

The general increase in size and capacity of the machine as might be expected is found to extend to the hose, since the usual sizes are 1½ inch, 1¼ inch and 1 inch. Unusual lengths are frequently employed, sometimes as much as 2,000 feet in a single line. Only hose of the highest quality will withstand the high pressures, and the ordinary couplings are useless. A specially constructed clamp coupling is required.

The spraying rod and nozzle are decidedly different from those used on mist sprayers. Rarely is a rod more than 6 or 8 feet long employed, and it is heavier and more rigid than the ordinary bamboo extension rod. The nozzle, as has been stated previously, is a straight bronze tube having a smooth aperture varying from one-eighth inch to five-sixteenth inch in diameter. (Such a spraying rod and nozzle are shown in Plate XIV, Fig. 1.)

A supplementary nozzle is sometimes employed to break up the solid stream into a fine spray at the nozzle tip in order to enable one to spray low trees and shrubs or the lower branches of high trees with the solid-stream outfit. The working principle of this nozzle is a sharp pin which centers in the solid stream or a deflecting flange at the sides. (See Plate XIV, Fig. 2.)

The solid-stream machines are used almost exclusively at present in the eastern and New England states, where they have been developed to meet the requirements of a machine for spraying large trees in a rapid, economical manner in connection with the suppression of the gipsy and brown-tail moths. Two are owned and operated in Ohio today, the village of Bratenahl, adjoining Cleveland, having secured a machine 2 years ago for use in eradicating a very small colony of gipsy moth which had been introduced, and more recently the city of Cleveland purchased one for general street and park use.

However, it is the writer's opinion that the machines of this type will in time come into general usage for street and park work throughout the Union, where such work is done, since they have demonstrated beyond question their superiority over the mist types for this purpose.

Operating a solid-stream sprayer.—The effectiveness and economy of the solid-stream machines depend largely upon the manner in which they are operated. Because of the tremendous volumes which these machines deliver, it is easy for untrained or careless operators not only to waste the spraying material but to do imperfect spraying as well. The force required depends, of course, upon the character of the work which is being done, but in street work, six to eight workmen should accompany each outfit. One man should drive the team and another remain in constant attendance of the apparatus. A third man should manipulate the nozzle, and between the nozzle man and engineer the closest harmony should exist, in order that they may work together. When the nozzleman for any cause is forced to shut off the nozzle, the engineer should immediately slow down the engine and when the nozzle is opened the engineer should instantly respond with full speed. If the engine is not slowed down, and the overflow valve fails to work properly, the hose is certain to give way; and if full power is not given immediately when the nozzle is opened, much mixture is lost before the pressure mounts to the proper point to give a first-class solid-stream spray. The people of Bratenahl found it advisable to send to New England for an experienced engineer and nozzle-

man to train the workmen to handle their solid-stream sprayer, and in the writer's opinion this is the wise plan to follow where the solid-stream type of spraying is being installed.

On account of the large size of the hose used and the unusual lengths commonly employed, a number of hose bearers should accompany each rig, the number depending upon the length of the hose. Many times five to eight are employed.

In general charge of the outfit should be a foreman, who not only looks after the work, but in addition answers questions and watches that pedestrians and vehicles are not soiled by the spraying material, since the average American passerby has peculiar ideas concerning his rights. For instance, the writer has observed persons deliberately walk into a mist of falling spray, or prompted by curiosity, stop their automobiles in the drift from the nozzle, and immediately become violently angry because their clothing or vehicle was soiled.

An attendant wagon should be provided for carrying the stock of spraying materials and other necessities, and the most convenient arrangement possible should be made for securing the water supply.

CAN THE AVERAGE MIST SPRAYER BE USED FOR SOLID-STREAM WORK?

Those who have realized the tremendous advantage of the solid-stream type of spraying over the mist type for city work often raise the question as to whether the mist machines may be equipped with solid-stream nozzles and be made to serve. During the spring of 1916 the writer conducted tests to develop information on this point at Wooster, Marietta and Cincinnati, using some of the larger types of the present day mist sprayers for furnishing the power, and a solid-stream nozzle of one-eighth of an inch aperture, such as is used in the New England States. Briefly stated, the results were but moderately satisfactory. A detailed discussion of the mechanical phases which the test involved will not be given; but the main difficulty which became apparent is the fact that the average mist sprayer today is built to maintain continuous pressures not greatly to exceed 200 pounds to the square inch, and the successful operation of a solid-stream nozzle involves the maintenance of pressures of 300 to 325 pounds per square inch at the pump and the deliverance of from 10 to 12 gallons per minute when the one-eighth of an inch solid-stream tip is used.

While the operators were able to maintain the desired pressure and deliver the required volume of liquid when every part of the machine was in perfect working order, they found that to do so

required the speeding of the engine and the overworking of the pump, so that in reality the machine was subjected to considerable strain. Moreover, it was found to be difficult to keep everything in perfect repair, such as the blowing out of cylinder packings, bursting of hose, the giving way of connections, and the like.

However, by giving the machine careful attention and the use of a 10- or 12-foot extension rod, they were nearly able to reach the topmost branches of the trees sprayed, none of which was over 75 feet tall. As stated previously, the results as a whole were moderately successful, since the operators were able to spray tall trees with a thoroughness and dispatch that would have been quite impossible by the mist method; but it would be impracticable to operate any sprayer of the ordinary mist type continuously under the strain to which these machines were subjected; and, if the solid-stream method is to be employed regularly, one of the stronger, heavy-duty machines should be secured for the work.

One of the machines used in the work is illustrated running under full pressure and delivering the spray in a solid stream in Plate XV, Fig. 2, and with the supplementary M. A. C. nozzle for making the flush spray in covering the lower limbs in Plate XV, Fig. 1.

CAN THE SOLID-STREAM MACHINES BE USED FOR MIST WORK?

While the practicability of using the mist sprayers for solid-stream work is perhaps doubtful, there seems to be no reason why the solid-stream sprayers cannot be equipped with mist nozzles and used for producing the mist spray. The foregoing statement is not based upon the actual experience of the writer, and, to his knowledge, the solid-stream sprayers of the eastern states are not used for mist spraying because they are employed almost exclusively in the application of poisons for leaf-eating insects during the summer months. Under Ohio conditions, however, there is considerable necessity for scale spraying, which must be done in the spring before the leaves appear; and, in order to be effective, every portion of the affected tree or shrub must be covered. The mist type of spray is much better adapted and more economical for the treatment of low-growing shrubs and trees in scale eradication; hence the ability of the solid-stream machines to produce either the solid stream or the mist spray, merely by a change of nozzles, renders them especially qualified for city use.

A SELF-PROPELLED SPRAYER DESIRABLE FOR CITY USE

With the decrease in the use of draft horses for city hauling, it is becoming increasingly difficult to secure the necessary teams

and teamsters for moving the horse-drawn sprayers of a city department, unless, of course, the department owns its own teams. Moreover, any team is considered slow in this day of rapid transit and the ones hired by the day are many times unreliable. Many times the writer has seen a spray rig and gang idle for half a day, or even a day at a time, simply because the driver failed to appear with his team. The loss of a single working day during the limited spraying season is a serious matter. At the present rate of growth in the usage of power vehicles, this already difficult situation is certain to become worse; hence the self-propelled sprayer is certain to come into general usage in the future.

The chassis of almost any one of the trucks of the medium heavy-duty type is well adapted to this purpose, and the power for driving the spray pump may be taken directly from the motor, thus doing away with the necessity of a separate engine for the sprayer proper. At times other than during the spraying season, the mechanism between the pump and engine may be disconnected and the spray pump and tank removed, thus leaving the truck free for general use. Thus, not only is less storage space required, but the amount of machinery lying idle during the time when spraying is not being done, is greatly decreased.

One machine of the type described is already upon the market and is illustrated in Plate IX, Fig. 2. This one, however, is constructed for particularly heavy duty, and it is the writer's opinion that a lighter machine could be built which would be more perfectly suited to existing Ohio conditions.

SELECTING THE MACHINE TO FIT THE NEEDS

As a final word concerning the subject of spraying machinery the writer wishes to emphasize again the value of study and discrimination in selecting the machine that is best suited to do the work required.

Before any single line of sprayers is adopted for the use of a city department they should be subjected to a very thorough examination by a mechanic well trained in the subject of spraying machinery, in order to avoid imperfections in mechanical construction, and in addition a representative machine should be given a thorough field test. This testing may involve the comparison of different makes under field conditions; indeed, it is often possible to induce the different companies to enter their machines into competitive tests.

After a given make and type of machine is decided to be superior to the others, it is then the best policy to install all the

machines to be used of the one kind, since experience has taught that many advantages accrue from such a plan. The possibility of interchange of parts and the maintaining of a stock supply of parts most liable to give way; the lack of confusion in the operation of the various machines when it becomes necessary to shift the workmen; and the chance to secure a low purchase figure by reason of buying in quantity, all these are features which indicate the desirability of the plan.

SPRAYING EQUIPMENT ACCESSORIES

The accessory equipment of a municipal sprayer is almost as important as the machine itself. Frequently the work is held up, precious time is lost, and wage outlays are wasted for the lack of some minor item of equipment which, if available, might prevent or right any trouble arising in the work. Frequently a machine is tied up several hours while someone makes a long trip across the city to get some tool to make an adjustment. Similarly the lack of proper protection for the men and horses makes for inefficiency and poor results.

A generous tool kit.—A tool kit should accompany each sprayer, with sufficient equipment to make any necessary adjustment on the machine, indeed, so that minor repairs may be made afield. Extra parts of the sprayer, recognized as likely to need replacing, should be carried along. Among these might be enumerated plunger cups and packing, extra nozzles and cut-offs and one or two extra lengths of hose.

Covers for horses.—Canvas or other waterproof material should cover the horses to protect them from the blowing and drifting spray. A city street with nearby tall buildings is filled with variable wind currents, and it is not always possible to keep the team and sprayer out of the falling spray. While no very serious harm is likely to follow a moderate amount of exposure to this condition, the hair may be roughened and made unsightly, and the harness becomes stained and unattractive. The comfort of the animals should also be considered. If protected, they are not so likely to become nervous and cause trouble.

Clothing for workmen.—All the workmen of a spraying gang should be suitably clothed for the work. Waterproof hats and coats may be worn, and the hands should be protected by leather gloves. The coat should extend below the knees, and preferably should be of material of moderate weight so as not to interfere too greatly with the freedom of the wearer. It need not be absolutely waterproof, since the wearer rarely encounters drenching spray and cloth

of moderate thickness is sufficient to shield from drifting spray mist. In addition to the articles mentioned, goggles are sometimes necessary for the protection of the eyes, and men with oversensitive skin sometimes find it necessary to wear a mask over the face. The latter is most likely to be necessary when the sulphur sprays are being used.

One should not expose himself more than necessary, for a few instances have been noted where rather severe injury resulted from continued exposure to spraying materials.

Lotions for protection of face and hands.—If one is to be subjected for an extended period to the action of caustic insecticides, the application of a simple lotion to the face and hands may avoid much discomfort. The lime-sulphur wash and the soda-sulphur washes are particularly caustic and even with the greatest care may cause severe chapping and cracking. The writer has seen men with hands so sore that they were forced to lay off several days for their hands to heal. Such cases usually follow careless and unnecessary exposure.

One of the most effective lotions which the writer has used is raw linseed oil with a few drops of carbolic acid added. When this is applied to the hands in the morning and at noon before work is started and in small quantities to the cheeks and nose if needed, one may avoid injury and the attending discomfort from this source. In municipal spraying a little attention given to matters of this kind by those in charge of the work contributes much toward the morale of the workmen and thus lends efficiency to the work.

SPRAYING MATERIALS

The progress in our knowledge of spraying materials during the last two decades has been quite as marked as has that concerning spraying machinery. Perhaps the most striking feature in connection with it has been a tendency to draw away from the complex formulae of many ingredients and to adopt simpler ones much less bothersome to prepare. This has been made possible by the standardization of spraying materials and by the appearance of a number of proprietary substances of great value, while the entire movement in turn has resulted in a tremendous impetus in the manufacturing of spraying materials on a commercial scale. The matter of standardization has resulted partly from competition and in part from the enactment and execution of regulatory laws.

There are a few well-defined groups of spraying materials today, each containing a few sprays, and from this comparatively

small number one is able to select a material suited to meet almost any situation likely to arise. In the present publication, however, those relating to insect control only will be considered.

The manner in which an insect feeds determines to a large extent the nature of the material used in controlling it. The biting insects, those which chew and devour parts of the host, particularly the surface portions, are best controlled with poison; but where the pest pierces through the surface of the host and takes its food in the form of sap, the poisons are not effective and the contact sprays must be employed; sprays which in one way or another kill by reason of contact with the animal body. Many pests upon which we ordinarily use poisons might be controlled with fair success with contact insecticidese if need be, but it is always advisable to use the poisons whenever possible for the reason that when poisons are used the pest may not be present when the work is done, but coming later may partake of the sprayed part of the host and be killed; whereas if the pest is not present when the contact sprays are used, it of course in coming later would not be affected by the treatment.

In the discussion concerning the various insecticides which follows, no attempt will be made to present an exhaustive discourse on all materials which can be used for the purpose, but rather to confine the remarks to a fairly complete treatment of the important and essential few.

THE POISON SPRAYS

Many poisons in many forms have been used in years past as insecticides, the more popular being Paris green, London purple and the arsenites of calcium and soda, but all on account of their variability and tendency to injure tender plants have lost caste for general usage, and we now depend almost exclusively in shade tree work upon a comparative newcomer, namely, arsenate of lead. Arsenate of lead possesses four attributes which particularly qualify it for use as a poison insecticide. These are its chemical stability, power of remaining in suspension when dissolved, tendency to adhere to foliage even after one or two rains, and lack of tendency to burn even the most tender foliage. The only serious criticism to be made against the material is that it is a slow acting poison.

Arsenate of lead was a homemade product at first and was prepared by combining chemically carbonate of soda and acetate of lead, but within a short time it appeared on the market as a commercial product in paste form and at present we have not only the paste but a powdered form as well.

Paste arsenate of lead.—Arsenate of lead in the paste form is white or very light gray in color, and depending upon the water content varies from a thin paste to a material of puttylike consistency. The thinner forms mix readily with water, but the drier forms are sometimes mixed with considerable difficulty, and in such cases the operation may be facilitated greatly by the use of an arsenate of lead mixer, as shown in Plate XIV, Fig. 3.

After the container has been opened and a part of the lead used, the top should be closed tightly to prevent the remainder from drying out. Likewise lead carried over the winter should not be permitted to freeze, since this too will dry it out. The dried or frozen lead, while still retaining its poisonous properties, is much more difficult to dissolve for use and at the same time is much less likely to remain well in suspension after it is dissolved. The addition of dissolved soap, at the rate of 1 or 2 pounds to 50 gallons of spray, has a tendency to correct this fault and also adds somewhat to the adhesive and spreading properties of the mixture.

For most insects arsenate of lead in the paste form is used at the rate of 3 pounds to 50 gallons of water, but for controlling some of the more hardy pests, such as elm-leaf beetle, gipsy and brown-tail moths, it should be used stronger—from 4 to 6 pounds to 50 gallons of water.

The dry or powdered form of arsenate of lead.—The dry form of this poison is of comparatively recent origin and seems to have been devised by manufacturers for three reasons: To create a new selling point; to minimize shipping expense by eliminating the excess of water, and to obviate the danger of drying out or freezing. The only item of superiority of great practical value from the consumers' standpoint is the last named, and this is counterbalanced by the fact that some of the dry forms are decidedly inferior in so far as their property of remaining in suspension is concerned. At the same time, in some instances the cost per gallon of diluted spray is considerably greater than that of a solution of equal strength prepared from the paste lead.

It is customary to use one-half the amount of lead in the powdered form that is used in the paste; thus, 1½ pounds is used to each 50 gallons for ordinary insect control, but for the more resistant forms as much as 3 pounds may be used. Little difficulty is experienced in dissolving the powdered lead for use.

When all points are considered, the writer has a slight preference for the paste form, but if the powdered form can be had at comparable prices and is found by test to equal the paste in other

respects, particularly in the property of remaining in suspension, he would make no discrimination. In buying in quantity, however, it is especially desirable to buy the powdered form by sample with a guarantee that the order equal the quality of the sample lot.

THE CONTACT INSECTICIDES

The present-day contact insecticides are much more diversified than the poison sprays, due no doubt in part to the fact that the missions they fulfill are more varied. For example, the poisons are few in number, are rarely used except when the plants are in foliage and, generally speaking, the strength of the solution does not vary greatly. But the contact insecticides necessary to fill the requirements are in greater number; are used when the plant is both in and out of foliage; and in point of strength of mixture vary from those suited for application to the most tender foliage to those for the treatment of the most resistant scale insects on dormant hardy trees.

The most useful of these contact insecticides may be divided into five groups, viz: the soap sprays, kerosene emulsion, nicotine sulphate, sulphur sprays and soluble oils. Each group possesses a distinct field of usefulness in city spraying; and while the subject cannot be treated exhaustively within the limits of the present publication, the matter will be discussed with sufficient detail to meet the practical requirements of the work.

Soap solutions.—Solutions of soap are among the oldest of the modern contact sprays. Their use is declining very rapidly at present, due in part to the fact that other materials are more effective and in part to the difficulty with which some soaps go into solution. With most soaps the application of heat is necessary to dissolve them, and this is frequently inconvenient and impracticable. However, because soap in some form or other is usually available, in special cases, where the necessity is urgent and when other materials are not to be had, it may be used to good effect.

Special insecticidal soaps are manufactured and may be furnished by most dealers in spraying materials. For the most part they have a fish-oil or whale-oil base and are quite commonly known as whale-oil soaps. There are other forms of insecticidal soaps, however, such as tobacco soap. If soap is to be used, these special insecticidal soaps are to be preferred to ordinary hand or laundry soaps, but the latter may be employed in an emergency.

The amount of soap to be dissolved for each gallon of spray depends upon the strength of the soap and upon the nature of the

insect under treatment. Some insects will succumb to weak soap solutions, while others require heavier doses. Most plant lice, however, are rarely able to withstand a bath of

Soap	1 pound
Water	5 to 8 gallons

Care must be taken, of course, in the spraying of tender growing plants not to make the solution too strong. The greatest field of usefulness for the soap solutions is in the treatment of plant lice.

Kerosene emulsion.—As with the soap solutions, kerosene emulsion is not so generally used at present as it has been in the past. Until the beginning of the last decade, however, it was the standard remedy for plant lice and similar insects. It is still recognized as an effective insecticide, and its decline in popularity has been due to the inconvenience and labor involved in its preparation. The stock emulsion is prepared as follows:

Soap (laundry or whale oil chipped)	½ pound
Kerosene (coal oil)	2 gallons
Water (preferably soft)	1 gallon

Dissolve the soap in the full amount of water and when this solution is boiling hot, remove from the fire and add the kerosene. Immediately and in the most violent manner possible agitate the mixture, one of the most satisfactory methods being to perform the mixing in a dasher churn, using the dasher for the agitating instrument. As a result of the agitation the soap solution and the oil emulsify, forming a white, creamy mass from which the oil does not separate. Ordinarily 5 minutes agitation will bring the desired result.

After the agitation is complete the resulting mixture is termed the stock emulsion. It is then ready for use, though it may be stored for some time if not immediately needed. For controlling plant lice and pests of a similar nature, the stock emulsion is diluted with 15 to 20 parts of water. Soft water is better than hard for this purpose.

Care should be taken in the use of kerosene emulsion to have the oil completely emulsified; otherwise the floating, free oil will cause severe burning if sprayed upon the foliage of plants, sometimes even proving fatal to the entire plant structure. Because of this chance defect in the emulsion either through improper preparation or through deterioration, and because burning may result also by insufficient dilution, kerosene emulsion is generally considered somewhat treacherous. Whenever possible, therefore, a safer and equally effective treatment is employed.

Nicotine sulphate.—Tobacco decoctions and teas have long been known and used as insecticides, but only within recent years have they been produced on a commercial scale in the form of a stable, constant product. This we now have in the highly concentrated form of nicotine sulphate which is used as a contact spray on plants in foliage more generally than any other material. Its greatest single field of usefulness is for the destruction of plant lice and similar pests. It is safe, is shipped in highly concentrated form, ana is rarely disappointing when correctly used.

For combating the average plant louse, use:

Nicotine sulphate	¼ pint
Laundry or fish-oil soap	2 pounds
Water	50 gallons

Without the addition of soap, the material is fairly effective; but when combined with the soap, its killing power is considerably increased.

Sulphur sprays.—While the sulphur sprays possess an extensive field of usefulness in horticultural activities in the country, it is more limited in city spraying. As strong dormant sprays they are used principally for the control of scale insects of the classes represented by the San Jose scale, scurfy bark louse, and the like; that is, most of the scale groups other than the large fleshy types, of which the magnolia and terrapin scales are examples. This limitation is due in large part to the fact that the sulphur sprays combine chemically with the paint on houses, resulting in serious discoloration and disfigurement. The soluble or miscible oils do not possess this disagreeable property, however; and, since they are equally effective for most of the troubles for which the sulphur sprays are used, they are gradually replacing the latter group in city operations, particularly for street use. Nevertheless, the sulphur-carrying sprays cannot be discarded completely from city work; indeed, in park and boulevard spraying they may be employed extensively for years to come. They therefore merit a fairly complete discussion.

Home-boiled lime-sulphur.—For 15 years or more the home-boiled lime-sulphur has been used successfully in controlling San Jose scale and similar scale insects, having been the first really successful spraying material devised for this purpose. Moreover, it furnished the basis for our modern concentrated sulphur sprays; and, while great progress has been made in the devising of new forms, the fact still remains that some growers have returned to the use of the home-boiled product after having employed the so-

called perfected sprays for some years. The revised formula, most commonly used at present is:

Sulphur	15 pounds
Lime	12 pounds
Water	15 gallons

The lime is slaked in the water (preferably hot), and while it is boiling violently the sulphur is added and boiled for 45 minutes to an hour. Live steam is by all odds the most satisfactory form of heat to use, since not only does direct heat applied to the bottom of a kettle or vat involve much stirring but at the same time the spray cannot be prepared in such quantity or of such an even quality.*

Commercial concentrated liquid lime-sulphur.—After the use of the home-made lime-sulphur solution became well established, the commercial, concentrated liquid appeared. As with any unperfected article, the results were variable at the outset; due in part to a lack of standardization in the liquid itself and in part to over-dilution, the general practice prevailing of diluting each gallon of the solution with 10 to 12 gallons of water.

At present the solution is well standardized. The concentrate should test 33° on the Beaume hydrometer and each gallon should contain 2.7 pounds of sulphur. For use, such a liquid should be diluted at the rate of 1 gallon to 7 gallons of water. The output of most of the commercial firms will meet these qualifications, but even now some variations are certain to occur; hence it is safest to rely upon the hydrometer test to determine the proper dilution of the concentrate. If the liquid is weaker than standard (that is, tests 32° or 31°) less water should be added; and, if it tests higher than 33° it naturally follows that more water should be added. Rarely, however, is the solution found to test higher than 34°. The table of dilutions for mixtures of various degrees of density which follows is approximately correct.

If the lime-sulphur solution tests	35°	Beaume, dilute each gallon with	8	gallons of water.
" " " " " "	34°	" " " " "	7½	" " "
" " " " " "	33°	" " " " "	7	" " "
" " " " " "	32°	" " " " "	6½	" " "
" " " " " "	31°	" " " " "	6	" " "
" " " " " "	30°	" " " " "	5½	" " "
" " " " " "	29°	" " " " "	5¼	" " "

The foregoing table refers to the minimum strengths to be used. The mixture can be applied at twice the strength recommended in the table, or even stronger, and no ill effects will follow, but by so doing the expense is considerably increased and no practical advantage is gained.

*The occasion would not likely arise in city spraying for necessitating the preparation of the home-boiled wash, but should such become necessary, the complete details of the work may be had by reference to Bulletin 169 and Circular 143 of this Station.

In orchard spraying the lime-sulphur sprays are used quite extensively in a very dilute form during the summer months when the trees are in foliage as a control for certain fungous troubles; but in street and park work the present demand for such work is negligible, and, to the writer's knowledge, the mixtures are never used for this purpose.

The question is often raised whether an oversupply of lime-sulphur can be carried over from one season until the next and retain its vital properties, also whether freezing injures the solution. In many instances there seems a partial deterioration when the mixture is held over winter since one frequently finds a considerable quantity of amber crystals in the bottom of the barrel. If such a mixture is used, it should not be diluted so heavily as normal mixtures. Freezing does not seem to injure the mixture unless the process opens up the container and causes leakage or free access of air. The mixture when stored should always be kept in air-tight containers.

Dry or powdered compounds of sulphur.—Powdered sulphur compounds are of recent origin and have arisen to fulfill the demand for a spraying material of a more concentrated nature than the liquid lime-sulphur concentrate—one more convenient to handle and lacking the disagreeable tendency to leak out of the container which the liquid concentrate unfortunately possesses. They are proprietary materials, each with its individual formula to be followed in its preparation for use; hence no instructions of a general nature can be given except to say that they are dissolved in water and applied as a spray. No dry material to be applied as a powder has yet been devised for scale control.

The efficiency of this class of materials for the purpose intended (the destruction of the San Jose scale, scurfy bark louse, etc.) is by no means as thoroughly established as that of the liquid spray, and in some cases, the cost per gallon of diluted spray is greater than that of comparative strengths of the liquid concentrate or the home-boiled solution. The Station has tested two of these materials which have yielded satisfactory results. These were: "The Soluble Sulphur Compound," which is not a lime sulphur but a soda sulphur, and "Barium Sulphur," which as the name signifies is a compound of barium and sulphur. Both materials seem fairly consistent chemically, but the Soluble Sulphur Compound is prone to deteriorate unless the container is kept tightly closed. When deteriorated the powder loses its bright yellow cast and becomes dirty white in color. Moreover, it increases greatly in bulk, sometimes swelling the containers badly, even to bursting the seams.

In addition to the two dry compounds just discussed, a dried preparation of true lime-sulphur, which has recently appeared, has been tested one season. The findings attending the work were not sufficiently conclusive, however, to warrant a statement of results.

The soluble or miscible oils.—The soluble or miscible oils, as the name suggests, mix readily in water. When so combined they form a white, creamy, oily spray which possesses good spreading and penetrating powers. The standard brands now enjoy the reputation of chemical uniformity and constancy of performance. These oils seem destined to serve an important mission in the field of shade-tree spraying, and particularly in the treatment of trees growing under city conditions proper. They are used extensively in the treatment of hibernating insect forms when the tree is dormant, principally for the control of scale insects. They should never be used as dilute summer sprays for the control of plant lice and other insect forms when the tree is in foliage. Some peculiar quality in the spray not yet understood causes severe foliage injury.

Two principal facts contribute toward assuring the soluble oils an important role in shade-tree spraying. In the first place, some of the more important shade-tree scales, as will be pointed out later, are not amenable to treatment with the sulphur sprays; and, in the second place, the oils are less likely to mar the paint of buildings than are the sulphur sprays.

In city shade-tree spraying, where the tree to be treated frequently stands on a narrow street or close to buildings, it can hardly be sprayed thoroughly without some of the mixture being thrown on, or the drift blowing on the buildings. Lime-sulphur combines chemically with the paint, forming a dark smudge if the building is light in color, and the smudge cannot be washed off after the action has been thorough. The miscible oils do not possess this property. If perchance a nearby building is soiled, because of the ready solubility of the material the paint may be quickly cleaned merely by directing a stream of water from the hose upon it.

In most instances the miscible oils are used at the rate of 1 gallon to 15 of water, though some investigators report it being necessary to use 1 gallon of oil to only 12 gallons of water in order to get killing results.

Used at the rate of 1 to 15, under normal price conditions, the miscible oils cost more per gallon of diluted spray than most other scale-destroying sprays. However, because of their superior spreading properties, less material is necessary for covering a tree; and when this point is taken into consideration, in the end, the miscible oils are but slightly more expensive than other materials.

Reasonable care should be taken in the application of oily sprays of any kind and the miscible oils are no exception. Excessive quantities should not be used, particularly to the extent of saturating the soil about the roots of the plant. Occasionally injury follows such proceeding. With even the most cursory care in their use, however, little danger of injury is likely to follow the application of these materials.

In using the miscible oils, special hose should be secured which is guaranteed oilproof, since otherwise it will quickly deteriorate. If possible, leather rather than rubber plunger packing or plunger cups should be used in the pump.

BANDING AND BANDING MATERIALS

Banding as a method of insect control unquestionably possesses much merit when properly executed, but the banding done in the average Ohio city or village more frequently results harmfully than beneficially. Banding finds its greatest field of usefulness in supplementing other measures. It is used extensively in New England in gipsy moth control work and in Ohio would be of value in supplementing spraying in tussock moth operations. It should be remembered, however, that it is not effective against all shade and forest insects but only against those which as larvae or adults use the trunk of the tree as a highway. It is a process that requires unflagging attention that the bands be kept in working condition during the period they are needed.

The great weakness of the banding method of protecting trees from their enemies is that too much confidence is placed in the process and too little attention is given the bands after they are in place. Thousands of trees are banded each summer in Ohio, the owners having the impression that the mere presence of the band will keep away all the pests. Moreover, the band may be given no attention, whatever, to keep it in good working order. In either event, other and perhaps better control measures are not applied and the trees suffer accordingly.

To summarize the foregoing, therefore, it may be stated that the abuse and not the use of bands in shade and forest insect control is to be avoided.

The following are some of the more important banding materials.

TREE TANGLEFOOT

This material is a commercial preparation possessing much the same consistency as the material with which the common tangle-

foot fly paper is covered. It operates by entangling the unwary insect and holding it until it perishes. This semi-liquid material is better than the fly paper which sometimes is tied about the tree trunks since insects sometimes crawl under the paper unless particular care is taken in applying it.

BANDS OF LOOSE COTTON BATTING

Loose cotton batting tied with a string around the trunk of a tree makes a fairly effective barrier for most crawling insects until it becomes matted through exposure or directly after rains.

BANDS OF BURLAP AND OTHER CLOTH

Bands of rough cloth are used quite extensively for banding trees but the principle involved is not that of forming a barrier over which the insects cannot travel, but rather to afford them convenient shelters in which to collect. When such bands are used, frequent examinations are necessary in order to collect and destroy the harboring pests.

The present publication embraces only the more important shade-tree insects that are likely to be of greatest economic significance. They are grouped in classes according to the manner of feeding. It is suggested that, if any difficulty is encountered in identifying a given depredator, the host index in the back of the publication be consulted freely, where there will be found the various insect pests listed under both the common and the technical name of the host.

LEAF OR FOLIAGE-DESTROYING INSECTS

It may safely be asserted that among the leaf or foliage destroying insects are found our most destructive shade and forest pests. Many not only are voracious, but are almost omnivorous in their feeding habits and in addition multiply very rapidly.

THE WHITE-MARKED TUSSOCK MOTH

(*Hemerocampa leucostigma* S. & A.)

Description.—The white-marked tussock moth is best known in the larval stage, the striking markings of which have given it its common name. The full-grown larva is a gorgeous creature about an inch and a half in length, with four dense white tussocks, or brushes, of hair on its back. Just behind these are two shiny red warts. The head is brilliant coral-red with a fringe of white hairs arising from the cervical shield and extending over it from above. Arising on each side and just back of the head is a pencil of black plumes about a half-inch long. A similar single pencil arises from the rear of the body. A broad, black band extends almost the entire length of the back and this is bordered by a yellow band on each side. The yellow bands are bordered with dark gray, and through the spiracles extends a thin black stripe. The caterpillar is yellow beneath. Clusters of white bristles arise from the sides of the body with a brilliant black bristle occasionally intermingled. (See Plate XVII, Fig. 1 and insert in Fig. 2.)

The newly-hatched caterpillar is pale in color, sometimes tinged with yellow, and clothed with long, variable hairs. Upon becoming full grown, the caterpillar seeks some sheltered position, if such is available, and spins a silken cocoon, in which are interwoven the hairs of the body. Abrasions or cracks in the trunk of the tree; cracks and crevices of nearby walls and fences; crannies in porches and the sheltering ledge of weatherboarding on dwellings, are examples of the sites chosen by the caterpillar for cocoon spinning. Sometimes the cocoons occur in great masses, as indicated by Plate XVII, Fig. 2. Frequently, however, when sheltered spots are not

readily available the cocoons may be spun on any part of the tree even upon the smaller branches, where one finds them usually with a leaf drawn down and bound into the cocoon. In cases of severe attack, the tree may be almost plastered, as indicated by Plate XVII, Fig. 3. This pernicious habit of spinning high up in the tree, as will be seen later, renders control measures much more difficult.

After the completion of the cocoon, the larva transforms into the pupal stage. In the pupal stage the sexes can be distinguished with comparative ease on account of the difference in size. The male averages about nine-sixteenths of an inch in length and the female eleven-sixteenths of an inch. In color both sexes are variable, ranging from yellowish green to very dark brown; usually they are mottled and two distinct spots of granular material are to be seen on the dorsum.

The greatest difference is apparent, however, in the appearance of the adult moths. The male is a grayish brown moth with a wing expanse of about 1¼ inches. The general shape of the body is that of the average typical moth. (See Plate XVIII, Fig. 3.) The female, however, is either entirely without wings or with but small rudimentary stubs, and is light gray in color. (See Plate XVIII, Fig. 2.)

The eggs are deposited in masses of from 100 to 500 each, usually on the outside of the female's empty cocoon. (See Plate XVIII, Fig. 1.) Covering the eggs is a frothy substance which in time becomes brittle and forms an effective protection. The individual eggs are nearly spherical and average about one-twenty-fifth of an inch in diameter.

Life history.—The winter is passed in the egg stage. In the latitude of Ohio the young hatch in late May. A month or a little more is required to complete the larval growth; thus in late June or early July the cocoon is spun and transformation to the pupal stage occurs.

The pupal period lasts for 10 days to 2 weeks, whereupon the adults emerge. Mating occurs with the female clinging to the old cocoon, and soon afterward the eggs are discharged in the mass as previously described.

About 2 weeks after their deposition the eggs give issue to the second brood of caterpillars, which in their turn pass through a life history similar to the one just described.

In Ohio there are two full broods, with the second usually the larger, and in the southern part of the State a third, or at least a partial third brood, occurs. The eggs of the last brood of the sum-

mer, whether it be second or third as the case may be, constitute the overwintering stage.

Nature of injury.—The newly-hatched caterpillars begin feeding upon the tender epidermis of the leaf of the host. As they develop in size and correspondingly in appetite and gastric ability, they devour the entire leaf structure with the exception of the midribs. When they are sufficiently plentiful the host may be defoliated, as shown in the accompanying illustrations, Plate XVIII, Figs. 4 and 5. Frequently the first brood of caterpillars devours the first crop of leaves, and the second brood in turn consumes the second output of leaves. Such a procedure seriously checks the development of a tree and lowers its vitality, thus rendering it susceptible to further harm by other agencies. Because of this fact a tree sometimes succumbs following repeated attacks by this insect, but as a rule the attacks do not prove fatal. Dr. E. P. Felt (3) cites an instance where the injury constituted the girdling of elm twigs at the beginning of the season's growth. This caused the twigs to die, break off and fall to the ground. Several instances are on record where the caterpillars have proved capable of severe injury to fruits. One of the most recent and most destructive occurred in western New York (4) where in some instances 85 percent of the fruit was mutilated by the feeding insects. Within recent years, and particularly the last two, young apple trees in some sections of Ohio have been injured perceptibly by the caterpillars of this species.

From the city standpoint the chief harm inflicted constitutes the partial or complete defoliation of the trees and the consequent detraction from their beauty and utility. Of less moment but not a negligible item, is the unsightliness of the egg masses and old cocoons as they adhere during the winter to tree trunks, sides of buildings, fences, etc. Unless removed by some mechanical method, these objects remain in place during the entire winter and give the property a neglected appearance.

Food plants.—Doctor Felt (5) reports the following list of food plants: "Linden*, horse-chestnut*, buckeye*, maples* (especially the soft and Norway), box elder, honey locust, apricot, garden plum, wild plum, garden cherry, chokecherry, rose, pear, apple, quince, ash, elm* (several species), sycamore or buttonwood*, butternut, black walnut, hickory, oak, birch, alder, willow, poplar, spruce, fir, larch and cypress."

The species has been noted as feeding in Ohio on most of the trees of the foregoing list and in addition has been noted on witch

hazel*, beech, ironwood, hazelnut and sour wood. Those marked with an asterisk are most severely attacked under Ohio conditions.

Distribution.—Geographically, the insect occurs over the entire section of the United States east of and including the states of the Mississippi Valley, and as far north as Nova Scotia. Ecologically, it is found more as a city pest than of the rural districts; hence we have come to think of it as specially inimical to the trees of densely-populated areas. In recent years, however, considerable injury has been done by way of defoliating apple trees on farms, and during the last two seasons rather extensive injury has been done in woodlands in southern Ohio.

Natural enemies.—The white-marked tussock moth is heavily beset by natural enemies; otherwise its depredations would be unbounded. For a few years it will be observed as gradually increasing in numbers until it becomes a veritable scourge; then it will be noted in the descendency, sometimes gradual and sometimes sudden. Following a severe outbreak, communities usually enjoy a few seasons of comparative freedom. The explanation of this procedure is that when the insect begins to increase in numbers its parasites also increase but for a time may not keep apace. At last they overcome the pest and thus veritably eat themselves out of house and home, whereupon they perish. No periodical regularity exists because associated factors are variable. The weather, for instance, has much to do with the development of host and parasite. Conditions which may be favorable to the one may not be so for the other.

Insectivorous birds in the rural districts constitute an important factor in its suppression. E. H. Forbush, ornithologist to the Massachussetts Board of Agriculture, lists forty-seven species of birds as feeding on hairy caterpillars and states that probably all these feed upon this pest. In the urban districts birds do not abound and therefore are not such a potent factor in its suppression.

Luckily the insect enemies of the white-marked tussock moth do not shy at man and his ways and are ,therefore, invaluable allies to him in checking the ravages of the pest in cities. As a result of the careful work of Dr. L. O. Howard (6), twenty-one primary parasites were recorded, and to these H. C. Yingling (7) has added two others, *Ichneumon unifasciatorius* Say and *Ichneumon seminiger* Cresson. Of the parasites listed, seventeen are Hymenoptera and six are Diptera. Hyperparasites totaling fourteen were listed by Doctor Howard. These included secondary, tertiary and possibly quarternary parasites. The primary parasites are of course the

friends of man; the secondary, his enemies because they prey upon his parasitic friends; the tertiary, his friends because they prey upon the parasites of his parasitic friends; and the quarternary his enemies, because they prey upon the parasitic enemies of the parasites of his parasitic friends.

A few predaceous enemies are known to feed upon one or more stages of the insect but these are not of great importance. Two Dermestids and some of the stink bugs are known to be of some value. Occasionally the latter may be found in considerable numbers, as shown by Plate XVIII, Fig. 6.

Infectious bacterial diseases constitute one of the important natural controls for this species in Ohio. When conditions are prime for the incubation and spread of the disease, hundreds of dead and putrefying tussock larvae may be found in heavy infestations. One of the most striking instances to come under the author's observation was in 1914. A clump of witch hazel (*Hamamelis virginiana*) in Rockefeller Park, Cleveland, Ohio, was defoliated, as indicated by Plate XIX, Fig. 1, by the first brood of caterpillars. The photograph shown was taken in early July. In other parts of the city, where the attack had been similarly severe, the hosts bore great numbers of cocoons and egg masses at that time. This clump drew one's attention when driving by; for, while the scourge was so severe that defoliation resulted, the cocoons and egg masses were not in evidence. Detailed examination revealed the fact that scarcely a specimen of either was to be found, but on the other hand the ground beneath the shrubs was heavily sprinkled with the dead and shriveled bodies of the caterpillars.

Specimens were submitted to Dr. G. H. Chapman, then of Bussey Institution, who reported that the infection was in every apparent respect identical with the "wilt" disease of the gipsy moth. So complete had been the destructive work of the disease that no second brood of caterpillars appeared, and the second crop of foliage on the witch hazel was not molested. By early fall the clump presented a normal appearance, as indicated by Plate XIX, Fig. 2.

Control.—Spraying with poison is the cheapest, most effective and most generally satisfactory method of control. As will be pointed out later, under special conditions this method may be supplemented or even supplanted by other measures, but in the main, it is in the poison sprays that we place the greatest dependence.

From 4 to 6 pounds of paste or half the amount of the powdered arsenate of lead should be used to each 50 gallons of water, and the application should be made just as early as possible after the caterpillars begin feeding. For the first brood this will be about the latter part of May and for the second brood some time in July.

If considerable numbers of egg masses are observed during the winter and the eggs appear healthy and virile, preparations should be made to spray for the first brood. By making the poison application at the time the first brood of young caterpillars are hatching, not only does one make the attack at the most strategic time, but, by thus eliminating the first brood of larvae, he may be reasonably safe in assuming that the second brood will be light—not enough to require attention. Moreover, such a procedure conserves the foliage of the tree so that the actual damage inflicted may be negligible, although the infestation may have been a severe one.

Collecting the egg masses is sometimes practiced—indeed, is recommended by some entomologists as the chief method of control. In theory it is admirable, but in general practice is a failure. If the infested trees are small and the work thus may be done with facility, the process is at once effective and practicable. The degree of infestation also should be taken into consideration. If the tree is moderate in size and but slightly infested, hand picking of the egg clusters may be practicable; but if the tree is heavily infested, the picking process becomes expensive to a prohibitive degree. No definite rule can be formulated as to just when hand picking is or is not practicable; but under any but extraordinary conditions, if a tree is at least 30 feet high, of spreading growth and moderately to severely infested, spraying is more practicable than egg collecting.

The practice of some cities to pay school children or other organizations by the measure for the collected egg masses has little merit. Usually the material so collected is taken from porches, fences, low down on tree trunks and similar situations from which it is questionable whether the hatching caterpillars would be able to make their way to the foliage of the trees. On one occasion the writer had the opportunity to observe as a spectator a competition among the different units of a boys' organization in an Ohio city in a tussock egg-collecting campaign. Where one egg mass was collected from tree trunks, fences, porches, etc. (comparatively harmless situations), at least ten were left to remain in the treetops, where conditions were ideal for their safe development. Such a campaign furnishes excellent material for newspaper stories where

the opportunity exists to count the number of eggs in an egg mass, the number of egg masses to the measure, and the number of measures collected. All multiplied together give the sum total of the eggs—a truly astonishing number. Because of its magnitude the fearful are quieted and after the shouting has subsided there is a tendency to rest on the oars, without further effort. If such is the result of the campaign more harm than good is done by it.

When collecting is done during the winter, the egg masses in no case should be destroyed. They should be spread out in wire containers not closer than 100 feet to the nearest tree and left remain until midsummer in order that the beneficial parasites may have a chance to emerge.

Banding the trees with mechanical barriers or with sticky substances is a common practice in cities. Under but one condition is this practice of great value. If the banded tree is free from the insect, and its branches do not interlock with infested or unprotected ones, banding prevents the wingless moths or migrating caterpillars from ascending the trunk and infesting the branches. If the top is already infested with some stage of the insect, banding is of little or no value. Again, banding would be of greater practical usefulness if the probability did not exist that the very young caterpillars are dispersed by the wind, blowing from one treetop to the next. When all these qualifying conditions are considered, it seems questionable if banding really is worth while. Moreover, many place complete dependence in the banding process, thus failing to provide really effective assistance to the tree, and as a result, their efforts are really harmful rather than useful.

THE FALL WEBWORM

(*Hyphantria cunea* Hub.)

Description.—Fall webworms are most frequently recognized by the unsightly light-gray silken webs on the trees in the late summer and early fall (see Plate XX, Fig. 2), and by the blackened, tangled web-remnants which remain on the branches over winter to detract from the appearance of the host.

The parent form is a moth which varies considerably in color, from pure white to white spotted with black. The eggs, deposited on the underside of the leaf, occur in clusters of 1 to 300. They are light yellow in color. (See Plate XX, Fig. 1, for illustrations of life history stages.)

The following description of the caterpillar is taken from the Fifth Report of the United States Entomological Commission.

"The caterpillars just born are pale yellow with two rows of black marks along the body, a black head, and with quite sparse hairs. When full-grown they generally appear pale yellowish or greenish, with a broad dusky stripe along the back and a yellow stripe along the sides; they are covered with whitish hairs, which spring from black and orange yellow warts. The caterpillar is, however, very variable both as to depth of coloring and as to markings. Close observations have failed to show that different food produces changes in the coloration; in fact nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker, with browner hairs than the spring generation."

The cocoon is thin and is spun on or near the surface of the ground. The pupa within is brown.

Life history.—The winter is passed in the pupal stage and in early June the adults begin to appear. From that time on they appear in straggling numbers, not all at a given time as a well-defined brood as do many insects. There is a time, however, in June and later in the summer when they are more plentiful than at other times. Shortly after emerging the eggs are laid; the caterpillars soon appear and begin feeding. At the very outset, the silken web, so characteristic of the species, is commenced and soon incloses the leaves upon which the insect is feeding. The web is increased in size as the caterpillars extend their feeding area; and since they are gregarious in their habits, by the time they are full-grown, 2 to 3 feet of the branch may be encompassed by the dirty white web in which is intermingled the castings of the insects as well as the browned remainders of the leaves which have proved too resistant to be used as food.

Upon the completion of larval growth, the caterpillars leave the web and wander about in search of a place on or just beneath the surface of the soil in which to pupate. The duration of the summer pupal period cannot be more than a few days, whereupon the second brood of adults appears and gives rise to the second generation of larvae. The winter is passed in the pupal stage.

Nature of work.—The real injury consists, of course, in the destruction of the leaf tissues of the host; and in cases of severe outbreaks, this is no inconsiderable item, as is indicated by a glance at Plate XX, Fig. 3. Occasionally, as the illustration indicates, the host may be almost defoliated. but more frequently just a branch here and there is attacked. In the latter case the actual injury is not so great as is the offense to the eye, particularly when the

attack occurs in parks and on city streets. A half-dozen unsightly webs actually are sufficient to ruin the esthetic value of even a very large tree.

Food plants.—The fall webworm is a general feeder. One hundred and twenty food plants have been listed by the U. S. Department of Agriculture, according to Doctor Felt (8). In Ohio, wild cherry seems to be the preferred food plant, with willows and various members of the Rosaceae also frequently attacked. Of the latter, the horticultural varieties of apple are quite susceptible, the insect proving a serious pest during some seasons. Here the fall brood works the greatest harm.

Distribution.—The insect occurs over nearly the entire United States east of Texas and Montana and is reported to be worse in the southern states. In Ohio certainly it is more abundant in the southern counties than in the northern.

Natural enemies.—Natural checks of a diversified nature and in considerable abundance prey upon this species. Among these agencies may be found insectivorous birds, egg parasites, predaceous enemies and internal parasites of the larvae; and in all probability the wilt disease previously referred to in the discussion of the tussock moth, plays an important role in the control of the species.

Control.—Except in the event of a widespread outbreak of exceptional severity, the best control measure lies in the destruction of the webs containing the feeding caterpillars. At least three practicable methods are available for this purpose . (1) If the trees are large enough so that the loss of a branch will not seriously mar their shape, pruning away the branch upon which the web occurs controls it with comparative ease. (2) If the trees are small, stripping away the nest and destroying it, without removing the branch is satisfactory. The work is much more pleasant if the hands are protected by a pair of gloves. (3) Burning the nests by means of an oil torch is practiced by some with success, but in the hands of careless workmen there is a possibility of considerable injury to the tree.

The final control measure, most practicable for use on large trees and in instances of severe, widespread outbreaks, is spraying with poisons, such as arsenate of lead at the usual strength.

THE BAG OR BASKET WORM

(*Thyridopteryx ephemeraeformis* Haworth)

Description.—One of the most curious and interesting of the shade tree pests is the bag worm. A glance at Plate XXI, Figs. 1 and 2, indicates more plainly than words why the creature was given

its name, since it illustrates the bags, or baskets, of the full-grown caterpillars. Many larvae spin somewhat similar objects but as a rule these are not constructed until the time for pupation is near at hand, while with the bag, or basket, worm one of the first larval acts is to spin a covering for its body, and this bag is drawn about by the larva during its feeding period. The fully-completed bag sometimes measures as much as 2½ inches in length, though the average length is about 1¾ inches. When opened, the larva within will be found with its head near the larger end. It is dark in color and gradually tapers from the head backward.

The larval bag serves as a cocoon and pupation occurs within its walls. The pupae of the sexes differ greatly in size, that of the female being much the larger. The adult male is a small, black moth with beautiful feathery antennae. The moth flies at will, while the adult female is a wingless grub-like creature which never leaves the protecting bag but to drop out and die after her life duties are completed. The eggs are deposited in a mass within the bag and are mingled with a quantity of light-brown woolly material. Reports made by various writers range from a few hundred to as many as 3,000 eggs within a single bag.

Life history and habits.—The winter is passed in the egg stage within the shelter of the weatherproof silken-walled bag, and further protected by the larval and pupal cases of the female. In May or June the eggs hatch, the young larvae escaping through an opening in the tip of the bag. As stated previously, one of the first larval acts is the spinning of the bag, the details of the process being lucidly set forth by Doctor Felt, (Memoir 8, New York State Museum, p. 125).

After the bag is constructed, the larva drags it about wherever it goes by protruding the forepart of the body, thus permitting the free use of the fore legs. If disturbed it quickly retreats within its shelter. If, however, one attempts to draw the caterpillar out of its bag, its body will be crushed or otherwise injured before it will release its hold.

The larva becomes full grown in August or early September. It then seeks a favorable situation and secures its bag from the upper end by a band of silk. Quite frequently the smaller branches of the host are utilized for this purpose, and where the attack has been severe large numbers of the bags may be observed so suspended. (See Plate XXI, Figs. 1 and 2.)

Soon after securing its bag, the insect passes into the pupal period which lasts but a few weeks. The males then emerge and

fly about seeking the females. The latter do not leave the bags at this time but merely protrude their bodies sufficiently to permit copulation, withdraw into the bags and deposit their eggs within the shelter of the cast pupal skin inside. Later the spent female wriggles out of the bag and falls to the ground. The eggs constitute the over-wintering stage, and it will thus be seen that there is but one annual brood of the insect. (See Plate XXII, for detailed illustrations of the life history.)

Nature of injury.—Two types of injury are effected by this insect. The first and by far the less important is that of occassionally causing the death of twigs by strangulation. When the larva hangs up its bag for the winter, occasionally enough silk of such a tough, lasting nature is banded about the twig that sap flow is cut off the following year, and the twig dies.

The principal harm done, however, is the destruction of the foliage by the feeding caterpillars. Occasionally complete defoliation occurs and this, particularly in the case of conifers, may cause the death of the host. (See Plate XXIII.)

Food plants.—Doctor Felt records a list of twenty-three food plants, which includes our more common trees. Hard maple, sycamore, horse chestnut, arbor vitae, cedar, sweet gum, black locust and willow suffer more severely under Ohio conditions than other hosts.

Distribution.—The range of greatest destructiveness in Ohio extends over the southern part of the State and in greatest intensity in the southwestern and southeastern sections. Occasionally considerable harm is noted as far north as Columbus, but rarely is the insect observed north of a line drawn east and west through the northern part of Franklin County.

Natural enemies.—On account of the tough protecting bag by which the insect is sheltered throughout almost its entire life cycle, birds do not constitute an important factor in its suppression. Even the cocoon-piercing woodpeckers find little inducement to attack the bags during the winter because the eggs within evidently do not prove such an attraction as the juicy pupae of other species. Fortunately, however, parasitic insects are not excluded by the bag and several are known to be of great usefulness in subduing the pest. The consensus of opinion of several writers is that the three most common are *Pimpla inquisitor* Say, *P. conquisitor* and *Allocota thyridopterigis* Riley. These insects invade the bag and their larvae develop on the body of the bag worm within, and later pupation occurs within the shelter of the bag. Beyond question these insects are largely responsible for the natural decline of bag-worm

scourges, since this insect, like others of our native harmful species, has its periods of prevalence and scarcity. During the last few years the amount of bag-worm injury has been increasing gradually, and at present considerable harm is being done in some sections.

Control.—Two methods of control are generally recognized. The safest, cheapest and most generally effective control measure in combating general outbreaks is spraying with poisons, but the bag worm larvae are somewhat resistant to the action of arsenicals, and hence the materials should be used in slightly stronger doses than are usually employed. Four pounds of arsenate of lead paste, however, is sufficiently powerful, particularly if applied when the caterpillars are small. When the over-wintering bags are plentiful and upon examination the eggs within are observed to be healthy, spraying plans should be made and the work should be done as soon as all the eggs have hatched. As indicated in the discussion of the life history, this will be in early June.

The second control measure, one which is practicable only in case the trees are small, consists in hand-picking the over-wintering bags. The work may be done any time after the foliage drops in the fall and before it starts the following spring. Light pole-pruners are useful for clipping the infested twigs. Like all hand operations and particularly where labor is costly, this control method has a limited field of usefulness and is practicable only under most favorable conditions. The collected bags should in no case be destroyed but should be placed in open containers, semiprotected from rain and distant from any food supply so that the parasites may have an opportunity to emerge during the following summer.

THE ELM LEAF BEETLE

(*Galerucella luteola* Muller)

Description.—The adult elm leaf beetle (See Plate XXIV) in shape, size and color more closely resembles the striped cucumber beetle than any of our other common forms. The color, however, is somewhat variable according to the season. The newly-emerged beetle is about one-fourth of an inch long, the general color being reddish yellow. Several black spots occur on the head and thorax and a black area extends down each wing cover, near and parallel to the outer margin. With the older and particularly the over-wintered beetles as they are observed in the spring, the reddish-yellow areas of the body become dark yellowish-green. The eggs are bright yellow, pointed and deposited large end down in double rows on the underside of the leaves. (Plate XXIV, Fig. 1, illustrates a characteristic cluster.) Usually several and rarely more than 25 eggs are placed together.

The newly-hatched larva is colored a mixture of yellow and black. When mature it measures about a half-inch in length and appears as indicated in Plate XXIV, Fig. 2.

The pupae are about one-fifth of an inch in length and are bright orange in color. They are found in greatest quantity at the base of the host.

Life history.—The adult beetle passes the winter in the shelter of attics, in piles of rubbish, or in any other protected place which is not too damp. With the development of tree foliage in the spring, it leaves its retreat and flies to the treetops where it begins feeding. After a short time the eggs are deposited, and these hatch in less than a week's time, whereupon the larvae begin feeding upon the leaf tissues.

From 2 to 3 weeks is required for the completion of larval growth, at the end of which the larvae make their way to the ground, great numbers pupating at the base of the tree, while others pupate in the grass and nearby trash.

The length of the pupal period depends in large measure upon the weather. If the weather is warm, the adult emerges in 7 days, but if cool, more than 3 weeks may elapse before it appears. There are at least two broods a season in Ohio, and some evidence supports the possibility of a third brood.

Nature of work.—The injury caused by the elm leaf beetle consists in the mutilation of the foliage of the host. This is of two types. The spring work of the beetles which have hibernated is characterized by holes eaten completely through the leaves as indicated by Plate XXIV, Fig. 9. The larvae, however, attack the under-surface of the leaves and chew away the epidermis, leaving a skeletonized effect as indicated by Plate XXIV, Figs. 7 and 8. As a general result of the two types of feeding, the foliage becomes mutilated, brown and functionless; and, if the attack is severe, the leaves fall. Sometimes, after the first crop of foliage is destroyed by the first brood of insects, the trees put out a second crop which in turn is destroyed. Defoliation for two successive seasons, particularly if dry weather prevails, is sufficient to kill the trees.

Aside from the harm done the host, the mass of insects which collect about the base of the tree is very repulsive, thus making the pest further objectionable.

Food plants.—Fortunately trees of the elm family only are attacked by this pest. Of the elms, the European varieties suffer most severely, but in the absence of the favored host other elms are

attacked with almost equal severity. The English elm (*Ulmus campestris*) and the weeping Camperdown elm are preferred to all others.

Distribution.—At present the insect is distributed in Ohio over an area not to exceed one-twentieth that of the State and is confined to the extreme southwestern section. It was discovered first at Dayton in 1904 and since that time is known to have spread north as far as Troy and to the southward. Cincinnati is spotted with out-breaks. In June, 1915, when a careful survey was made in Cincinnati by the Board of Park Commissioners and the State Bureau of Nursery and Orchard Inspection, the pest was recorded in forty-seven sections of the city and its environs. Some persons on whose premises the pest was found said that it had been present for at least 7 years, but this point is questionable.

During the years of its residence in Dayton, it has become thoroughly disseminated throughout the city and annually does much harm.

While the elm leaf beetle is a comparative newcomer in Ohio, it has been in the United States about 80 years, having been established first at Baltimore, Md. It now occurs in most of the eastern and New England States and is thoroughly established as far west as Ohio, Indiana and Kentucky, and has been reported recently from the Pacific coast.

Natural enemies.—Rigorous seasons and natural enemies undoubtedly have an important bearing in limiting this pest, since unquestionably it is more abundant and destructive some years than others. Of these natural controls, the one most active which has come under the observation of the writer is the white fungous disease, *Sporotrichum globuliferum.* During some seasons this has been noted as extremely abundant, particularly as attacking the pupae and adults.

This is a true fungous disease. After the spores gain access to the body of the insect they germinate, sending the white, root-like mycelial threads throughout the body. After the death of the insect the fungous growth in many instances completely envelops the body of the host, obscuring the details of its anatomy and making it appear as a shapeless snow-white mass. In other examples the growth but partly obscures the dead host.

Most of the diseased insects are found in the grass and trash about the base of the tree but many of the dying and dead beetles lodge in the cracks of the tree trunk. A glance at Plate XXV, Fig. 2, will convey some idea of the activity of this agency, although the

illustration scarcely does the case at hand justice, since many specimens which were present are not shown by the photograph. The year this photograph was taken (1914) the disease was a very important control agency at Dayton, Ohio. Thousands of dead insects were found under every infested tree.

One of the stink bugs, *Apateticus maculiventris* Say, is an active destroyer of the larval, pupal and adult stages and has been observed a number of times with one or the other stages of the insect impaled upon its beak. (See Plate XXV, Fig. 1.)

In addition to the foregoing, Doctor Felt (9) records a number of other insects as destructive of this species, and it is likely that at least some of these and others as well are active in this State.

Control.—The most effective control method consists in spraying with poisons at the time the young are most abundant. The first spraying of the season, therefore, intended to control the first brood of young should be made a week to 10 days after the foliage is fully developed. If this treatment fails to subdue the outbreak, a second may be made in midsummer against the second brood. In timing these sprayings, however, it is best not to rely specifically upon dates but rather to fit the application to the time of the appearance of the depositing and hatching of the yellow egg masses. Arsenate of lead is most generally used for the work. Rarely is it used more dilute than 4 pounds to 50 gallons of water and some entomologists recommend as much as 5 pounds to 50 gallons. (See Plate XXVI, Figs. 1 and 2.)

Banding the trees with a sticky material, such as tree tanglefoot, in order to capture the descending larvae when migrating to the base of the tree for pupating is sometimes used, but the results do not justify the expense of application. Bands of burlap around the tree trunks intended to attract the larvae as suitable pupation centers likewise work better in theory than in practice, since the labor of tending the bands is considerable and not all the beetle larvae choose to pupate under them. While of some value, banding as a whole scarcely can be considered a satisfactory control measure.

Destroying the masses of pupae and larvae at the base of the tree is practiced by some as a control measure. It is of considerable value. The work may be done by an application of hot water or any contact insecticide, such as lime-sulphur, kerosene emulsion or soap solutions. The former is perhaps most practicable.

As a final recommendation pertaining to the control of the species, it is suggested for infested districts or those likely to become infested at an early date, because of close proximity to existing

outbreaks, that the planting of English and Camperdown elms be discontinued because of their high susceptibility to attack.

CANKERWORMS

(*Alsophila pometaria* Harris)
(*Paleacrita vernata* Peck)

Two distinct species of cankerworm exist in Ohio, commonly known as the fall and the spring species. They are similar in both appearance and habits, and since control methods are practically identical the two insects will be considered together. For a good description of the technical differences of the two species the reader is referred to the "Manual of Fruit Insects" by Slingerland and Crosby (10).

Description.—Cankerworm larvae are slender, looping caterpillars, belonging to that group commonly called measuring worms. When full grown they measure about an inch in length and are very slender. (See Plate XXVII, Fig. 4.) They vary in color from a light variable brown to almost black, though most of them bear some form of striping which runs lengthwise of the body, more frequently the stripes being narrow, faint yellow on a dark background than any other form and color. The male moths have a wing expanse slightly over an inch, the hind wings being light gray and the fore wings somewhat darker in color. (See Plate XXVII, Fig. 1.) The female moths are wingless, medium gray in color, and about one-half of an inch long. (See Plate XXVII, Fig. 2.) The fall species has in most cases a dark broad line extending lengthwise of the back.

The pupae of both species are found slightly beneath the surface of the ground, that of the fall species being inclosed in a thin, tough, silken cocoon, while the spring species has little more than its earthen cell for protection.

The eggs of the spring species are oval, iridescent-metallic and are not deposited in regular formation, while those of the fall species are dark grayish-brown, resembling in shape tiny flower pots and bearing a dot and ring on the top. They are deposited in regular formation, sitting on the small end and most frequently are found as bands surrounding the smaller twigs. They average in the neighborhood of 200 in a band, though bands of twice this number have been observed. (See Plate XXVII, Fig. 3.) Sometimes they are deposited in patches on the trunk and larger limbs of the tree.

Life history.—The eggs hatch in the spring with the development of the foliage and at once the tiny caterpillars begin feeding. From the very outset, the insects possess the power of spinning

silken threads, and it has been long and well known that the larvae would lower themselves by the spun thread if the tree or branch was sharply jarred. However, it was not until recently that W. H. Goodwin (See Monthly Bul. Ohio Agricultural Experiment Station March, 1918), observed that the very tiny larvae have the habit of spinning out a length of thread, letting all holds go and sailing away in the breeze. At the end of the second day's feeding, however, their bouyancy is so decreased that they are no longer able to float. Some larvae were observed by Goodwin to float as far as 25 rods.

The observations of Goodwin pertaining to the floating habit of the larvae have done much to clear up the mystery of the spread of the insect. Because of the wingless state of the female, spread cannot be effected through the agency of adult flight, nor is it possible through the movement of egg masses; nevertheless, in actual field conditions the spread sometimes is appalingly rapid, and in the drifting of the larvae lies by all odds the most logical explanation. At the same time these observations have done much to alter control recommendations as will be pointed out later.

From 4 to 6 weeks' time is occupied in larval growth, and at the end of this period the worms descend to the earth, enter to a depth of from 1 to 4 inches and pass to the pupal stage.

From this point the life history of the two species is quite different. The spring cankerworm, so far as is known, invariably remains in the soil until the following spring, but under some conditions the adults of the fall species may emerge in late fall, though in Ohio it seems that most emerge in late winter or very early spring. Weather conditions have much to do with the exact time of emergence. According to Goodwin's observations, 5 to 8 successive days of temperature above freezing at night and in the neighborhood of 50° F. during the day, usually will bring out the brood. The entire brood, however, does not appear at once, but the spring emergence may extend over a period of 6 weeks or more.

Because of the wingless condition of the females they crawl up the trunk of the tree, most of them preferring to make the journey during the early hours of darkness. As the females ascend, the males visit and fertilize them, adn egg deposition by the fall species, takes place for the most part on the twigs high up in the top of the tree but the spring species oviposits lower down on the trunk and limbs of the host, tucking the eggs away in tiny clusters beneath the flaky bark scales.

As previously stated, the eggs of both species hatch with the appearance of the foliage in the spring.

Both the fall and the spring cankerworms have but a single brood per year.

Nature of work.—The chief harm inflicted by cankerworms is the destruction of all or part of the foliage of the host. (See Plate XXVIII, Figs. 2 and 3.) If the insects are plentiful the tree may be entirely stripped of its leaves, and if the infested area is extended it presents the aspect of having been overrun by fire. Several successive recurrences of the scourge is sufficient to kill the trees, and this not infrequently occurs under Ohio conditions but more often farther west, particularly if the visitation is succeeded by a dry, unfavorable summer. In the case of fruit trees and particularly apples, the young fruit is sometimes badly mutilated; but even if this is untouched by the caterpillars, the weakened condition of the tree due to the impairment of its foliage seriously injures the size and quality of the fruit. Always the top of the tree, whether it be fruit or forest, is most severely injured; indeed, the top half may be all but completely defoliated while the lower limbs may be scarcely touched.

Food plants.—Cankerworms are cosmopolitan feeders, being able to subsist on a wide range of trees and shrubs. Of the fruits apple is much preferred, and plum is occasionally injured. Of the shade and forest trees the linden or basswood suffers more severely than other species, through elm and maple are almost equally harmed. Other host trees observed in Ohio are red oak, white oak, white ash, black oak, chestnut, Craetegus, European linden, beech, ironwood, black walnut and shellbark hickory. Doubtless by further investigation this list could be enlarged considerably.

Distribution.—Not only are cankerworms known to infest all sections of the State, but they abound in many other sections of the United States as well. In Ohio the pest most frequently infests the farm orchard and woodlot, but at present it is occurring in exceedingly destructive numbers in the Middle West under city conditions whole streets being defoliated by it.

It is an irregular visitant, its appearance in a community usually starting with small numbers, which gradually increase until the outbreak assumes the proportions of a scourge. This may last for two or three seasons and the pest may then suddenly almost disappear. For the last 3 years the pest has gradually increased in plentifulness about Wooster, and as shown in Plate XXVIII, Fig. 3, in some localities in the State has caused an almost complete defoliation of woodlands.

Natural enemies.—Unfavorable weather conditions in all likelihood constitute as effective a check on the species as any other agency. If the weather suddenly turns cold, or if a heavy snow or ice storm occurs at the time the brood is emerging, many are destroyed. Moreover, it has been observed (11) that freezing weather when the larvae are young kills many of them.

Native birds are an important control agency. Forty-two species of native birds feed upon these worms, according to Prof. J. S. Hine of the Ohio State University (12).

A considerable number of insects are known to prey upon and parasitize cankerworms in their various stages. The predaceous beetles and wasps, attacking adults and larvae, Ichneumonid and Tachinid parasites attacking the larvae, and Chalcid parasites attacking the eggs, all contribute in subduing outbreaks of the pest.

Control.—Two methods of control are available. Since each has its good and weak points, which depend much upon the conditions under which the cankerworm outbreak occurs, the selection of the most suitable method depends upon the judgment of the operator.

In years past the control method most commonly recommended has been banding the trees with some sticky substance, such as tree tanglefoot as described on page 205. The object of banding was to prevent the female cankerworm moths from ascending the trees and depositing their eggs in the preferred situations. In theory the idea works perfectly; in practice it is found to have limitations. Its greatest deficiency lies in the fact that the adult moths do not all ascend the tree within a period of a few days, but that some of the fall cankerworm adults may go up in the fall and deposit their eggs while others may wait until spring, and during the spring the emergence of both fall and spring moths may extend over a period of several weeks. It will be seen, therefore, that in order to insure success, the bands must be in place, and in working condition for 3 or 4 months. Cold weather and blowing dust and trash coat the sticky-band surface, and unless the band is freshened, this permits a safe passage of the insects over it.

The second weakness of the method is that if the brood of cankerworm moths is very heavy, and the sticky bands are not inspected from day to day, the dead bodies of the captured moths completely bridge the band and late-comers cross over in safety. Such a band is illustrated in Plate XXVIII, Fig. 1. W .H. Goodwin records having caught as many as fifteen thousand female cankerworm moths on a single band, and when one considers the fact that

in addition to the females, many winged males also are captured as they are attracted to the females and attempt to copulate, the bridging of the band becomes a comparatively easy matter. It will be seen from the foregoing that if the banding method is relied upon, the bands must be placed in position in good season and must be inspected at frequent intervals to maintain a sticky surface. Particular attention should be paid them during the period when the spring brood is most likely to emerge in quantity to prevent the bands from becoming bridged.

Nevertheless if by careful attention the banding method can be made to serve the purpose intended, it is the cheapest form of protection, particularly in the case of large trees which are difficult and expensive to spray.

The second method of control, as opposed to banding, is spraying with poisons. The application should be made when the cankerworm larvae are very small. A good rule to follow is to spray when the leaves are about an inch long. Arsenate of lead, used at the strength of 5 or 6 pounds of paste or an equivalent amount of powder to 50 gallons of water, is satisfactory, but particular emphasis should be placed on spraying the tops of the trees, since at this point cankerworms work their greatest havoc.

Where trees, whether fruit or shade, are annually sprayed with poisons soon after the leaves appear, the cankerworm pest is negligible.

THE BLACK WALNUT DATANA

(*Datana integerrima* G. & R.)

At its present rate of destructiveness the walnut datana bids fair to eliminate black walnut from our list of native Ohio trees. Thousands of trees are dying annually from its work. It is therefore of sufficient importance to merit careful attention.

Description.—This insect is rarely seen except in the larval stage, when it is most frequently noted as clusters of caterpillars feeding on the foliage chiefly of black walnut. When first hatched, the larvae have black heads and brick-red bodies, the latter bearing faint stripes. As the larva ages, the brick-red coloration deepens and the lines become more distinct; long, sparse hairs appear, and in the final, or full-grown larval stage, the body is black, very indistinctly lined and generously adorned with a growth of long white or dirty gray, frowzy hair. The full-grown, well-fed caterpillar measures a little more than 2 inches in length. (See Plate XXIX, Fig. 5.)

The pupa is found beneath the surface of the soil at a depth of a few inches, is hard, dark brown, and measures a little more than a half-inch in length. (See Plate XXIX, Fig. 2.)

The adult is a heavy-bodied moth measuring nearly 2 inches across its expanded wings. The general color of the fore wings is buff brown, with darker lines running crosswise of them in an irregular manner. The hind wings are lighter in color and are not marked by the cross-lines. (See Plate XXIX, Fig. 1.)

The eggs are small and dull white and are deposited on the underside of the leaves in masses of 300 or more. They are not found frequently. (See Plate XXIX, Fig. 3.)

Life history and habits.—In July or early August, the moths emerge from their pupal cells in the earth and fly about. Shortly the eggs are deposited and in a little while the larvae hatch and begin feeding in clusters. This gregarious habit is maintained during the entire larval growth, except during the last few days when the cluster becomes separated and the insects exhibit a tendency to wander about. At certain intervals during larval growth, all the caterpillars of a feeding cluster will start in unison to crawl down to one of the larger branches or the trunk of the host, leaving as they travel a faint, silken trail. They finally assemble in a cluster lightly held together by silken threads. Frequently several hundred caterpillars are found thus clustered together, making a mass a foot or more long and half as broad. This hairy, compact mass presents a very unsightly appearance and invariably reminds the writer of the carcass of a dead maltese cat with its appendages tucked under it, nailed to the tree. (See Plate XXIX, Fig. 4.) The caterpillars remain clustered several hours, during which time each one molts or sheds its skin. When the process is complete they retrace their silken trail back to their feeding grounds. This performance is repeated several times during the process of larval growth. When disturbed the larva has the habit of suddenly elevating both ends of the body and remaining rigid in a particularly threatening attitude.

When the larvae reach maturity they pass to the soil and after burrowing down beneath the surface, transforms to the pupal stage. The winter is passed in this condition.

Whether there is more than one brood in Ohio has not been definitely decided, although it is unlikely. However, the writer has observed full-grown caterpillars as early as August 23 in northern Ohio and as late as October 4 in southern Ohio, and it may be possible that two broods occur in southern Ohio.

Nature of work.—The prime injury caused by the walnut datana is the destruction of the leaves. Since the larvae feed in clusters, it is natural that they should destroy all the leaves on a limb, or a part of the tree before moving, and this actually is what occurs. Sometimes but one or two limbs will be defoliated, sometimes half of the tree, but in case of a severe attack the entire tree may be defoliated, as is illustrated in Plate XXX. Two or three annual defoliations are sufficient to kill the tree. Isolated trees, or trees in small clumps are more susceptible to injury than groves of the preferred host, or when such are located in woodlands. It, therefore, quite frequently occurs that a prized lawn tree or a landmark may fall prey to this species and be destroyed.

When the insect infests lawn trees, the caterpillars are very obnoxious during the wandering period just before pupation when they may invade porches or houses, drop on passersby, and in general render the lawn quite useless for recreation because of their repulsive appearance and the danger that their crushed bodies and droppings will soil clothing.

Food plants.—Their favorite food is the foliage of the black walnut, and under Ohio conditions where this is available other trees rarely are harmed. However, the butternut, or white walnut, sometimes is injured in this State to a considerable extent and in the southern states the insect is recognized as a destructive pest of the pecan, both cultivated and wild. A few other trees have been listed as host plants. These are hickory, beech, oak, willow, honey locust, thorn and apple.

Distribution.—This insect has been taken in Maine and is a pest in Florida, and in all likelihood it occurs throughout the eastern United States. Westward it has been taken as far as Kansas. Thus its range is obviously quite extended. Of this area, the pest is most harmful in the south and central part.

As stated previously, isolated trees or trees in small clumps are attacked with greater severity than those distributed through woodlands or those growing in groves of pure stands.

Natural enemies.—Four parasites attacking the eggs are reported from Florida. These are *Trichogramma minutum* Riley, *Baryscapus* sp., *Telenomus sphingis* Ashm and *Ooencyrtus* sp. In the opinion of H. M. Russell, these egg parasites are sometimes of sufficient significance to affect seriously the numbers of the host. In 1907, when the walnut datana was particularly abundant in the fall, but the following spring, when egg parasitism was prevalent, the numbers of the first brood were greatly decreased.

Careful observations have not been made in Ohio for egg parasites, but Tachinid flies attacking the larvae have on many occasions been noted as abundant. It seems that larval parasitism takes place most frequently when the larvae are crawling through the grass, seeking a favorable place to enter the ground. At that time the flies may be observed hovering over the larvae, seeking an opportune instant to swoop down and deposit their glistening white eggs on the back of the host. The eggs are secured by an adhesive, mucilaginous secretion, and are very plain to the unaided eye. Sometimes a considerable number will be found on the body of a single larva. The larvae resent the process and attempt to prevent it by squirming about and swinging the head from side to side in a rapid jerky movement. Unquestionably the Tachinids play an important role in the natural suppression of this species. The yellow-billed cuckoo, *Coccyzus americana*, is reported (14) as one of the more active bird enemies of the species.

Methods of control.—Unfortunately under present Ohio conditions it is rarely practicable to attempt the application of artificial control measures except in the case of trees prized for their shade or ornamental purposes, nor is the timber or nut crop of sufficient value to warrant the expense of the treatment. Several methods are available to combat the species. If the trees are small and readily sprayed, an application of arsenate of lead at the usual strength at the time the caterpillars begin feeding is adequate. Pruning off the infested branch and destroying its burden of clustered caterpillars is resorted to by some. The caterpillars may be destroyed also when they collect for molting on the trunk or larger branches of the trees. Crushing and scalding with hot water are the means most commonly adopted for this purpose.

THE YELLOW-NECKED APPLE DATANA

(*Datana ministra* Walker)

The yellow-necked apple datana, while primarily an orchard pest, sometimes does considerable harm to ornamentals and has been noted as becoming increasingly abundant in woodlands during the last two seasons.

Description.—The full-grown larva measures about 2 inches in length, has yellow and black stripes extending lengthwise and is sparsely covered with whitish hairs. The upper part of the neck, or thoracic shield, is yellow, and on this account the insect is given its name. As is characteristic of the Datana group, it elevates the ends of the body when disturbed. (See Plate XXXI, Fig. 3.)

The pupa is dark brown and about a half-inch in length. (See Plate XXXI, Fig. 2.)

The adult is with unusual difficulty distinguished from the preceding species. (See Plate XXXI, Fig. 1.)

The eggs are oval, white, and deposited in a mass on the underside of the leaf.

Life history and habits.—The moths fly about in early summer and deposit their eggs, and the caterpillars soon hatch. During the early stages of larval development the insects have the power of letting themselves down on silken threads when disturbed, but as they grow they lose their power and merely drop to the ground if jarred or shaken violently. By late September, most of the larvae are mature, whereupon they enter the soil to a depth of a few inches and transform to the pupal stage. In this condition they pass the winter.

Nature of work.—The injury by this species is confined to the destruction of the foliage of the host. In cases of severe outbreaks the injury may amount to complete defoliation, though this occurs more frequently on young than on old trees.

Food plants.—Plants of the family Rosaceae are more severely injured than others. The following hosts are recorded in the literature or have been observed by the writer: apple, pear, cherry, quince, linden, walnut, hickory, white oak, black oak, chestnut, beech, witch-hazel, hornbeam, birch, locust, sumac, sour-wood and sorrel tree.

Distribution.—This insect occurs in nearly all sections of the United States. Ecologically it is more destructive in orchards than to ornamentals and woodland trees.

Control.—When the infested trees are small and the attack is not too severe, collecting the clusters of feeding caterpillars is effective and at the same time practicable.

In severe outbreaks and on large trees, spraying with poisons is cheapest and best. Arsenate of lead at the usual strength is satisfactory.

(*Datana drexelii* Edwards)

Description.—Both the adult and the larval forms of this species so closely resemble the yellow-necked apple datana that the two insects are frequently confused, the similarity being particularly great in the adults. However, after the differences have once been noted, at least the well-grown larvae are fairly readily distinguished. The principal points of difference between the two are as follows: The general body color of *D. drexelii* is somewhat

lighter than that of *D. ministra;* in the latter the thoracic shield only is yellow, while with the former the yellow encompasses the entire neck; and with *D. ministra* the yellow lines on the sides of the body extend back to the tip while on *D. drexelii* they end in a jumble before the tip is reached. The eggs and pupae are also very similar, the eggs being deposited on the leaves and the pupae, of course, being found beneath the surface of the soil.

Life history.—The life history is so similar to that of *D. ministra* that an account of it is not necessary. There is probably but one brood per season.

Nature of work.—The injury by this species is confined to the destruction of the foliage of the host; but, since the insect is not generally prevalent and abundant in Ohio, the actual damage is not great.

Food plants.—Of the food plants, witch-hazel, walnut, linden, sassafras, *Vaccinium stamineum* and *Vaccinium corymbosum,* the writer has found this insect more frequently upon sassafras than upon any other host.

Distribution.—This species has been observed more frequently by the writer in the southern part of the State than in other sections. Further it is known to occur in New York and New Jersey.

Control—The execution of control measures rarely will be found necessary. Spraying with poisons doubtless would be effective.

(*Datana major* Grote and Robison)

Description.—In all forms excepting the larval, this species resembles *D. ministra.* The well-grown larvae, however, is decidedly different. The head is reddish as is also the cervical shield and bases of the legs. The most striking dissimilarity, however, is the fact that the yellow parallel lines extending lengthwise of the body are broken with black, giving the insect a finely spotted appearance. It has been taken by the writer but once in the State and seemingly is of rare occurrence. It is therefore at present of no importance as a pest and is treated here in the foregoing brief manner merely to assist those in identifying it who might casually encounter it.

THE LOCUST LEAF BEETLE

(*Chalcpus dorsalis* Thunb.)

The most destructive single species of the hilly woodlands of southern Ohio is the locust leaf beetle, and because of this fact it merits careful consideration. The browning of the foliage of the black locust in the summer and fall is due to the feeding of the adult beetles and to the mining of the leaf tissues by the larval form.

Description.—The adult of this species is a hard-shelled, flat beetle slightly less than a quarter of an inch long and about half as broad. Beneath, the insect is shiny black and above, the antennae, head and legs are likewise black as is also an area down the midle of the wing covers. The thorax and a part of the wing covers are orange red. The black area on the wing covers is triangular in shape, the coloration starting at the base of the median line and gradually widening posteriorly. It varies considerably in width with different individuals, sometimes being very narrow, while in others it is so wide as to embrace nearly all the tip of the wing covers.

The wing covers each bear four strong ridges and the areas between the ridges, as well as the thorax, are densely punctured. A glance at Plate XXXII, Fig. 1, will convey a general impression of the appearance of the adult beetle.

The thin, flat, oval eggs are deposited on the underside of the leaf and piled one upon another, somewhat shingle-wise and covered with brownish fecal matter which hardens soon after it is deposited. Rarely are more than five deposited together.

The larval stage is passed within the shelter of mines which the insect constructs within the leaf tissue. (See Plate XXXII, Fig. 4.) The larva is about one-fourth of an inch in length, somewhat flattened and tapers but little. When full grown it is yellowish white, with the true legs, head, thoracic shield and anal shield, coal black. The segmentation of the body is plainly marked, and distinct lateral tubercles are borne by each abdominal segment. (See Plate XXXII, Fig. 2.)

The pupa also is found within the leaf mine and in many respects resembles the larva. The body, however, is more pointed and slightly shorter. The folded wing covers and legs are plainly visible on the underside. (See Plate XXXII, Fig. 3.)

Life history and habits.—The adult beetles hibernate over winter in sheltered situations, such as crevices in the bark of trees and under the litter of the forest floor. Coincident with the development of the foliage of the black locust in the spring, and sometimes slightly in advance of that time, the beetles emerge and begin feeding, this occurring usually after mid-April. After a short time the eggs are deposited in the manner previously described. They hatch soon, the larva breaking through the underside of the shell and eating its way into the leaf tissue and forming a mine. All the larvae of the egg mass occupy a single mine for a time, but in a little while new mines are constructed and the insects live singly. Several

mines probably are constructed before the larva reaches maturity. The writer has observed nearly full-grown larvae in the act of constructing new mines, eating through the upper surface of the leaf as a starting point.

Pupation occurs within the mine. Differing from most pupae, that of this species is very active, easily shifting its position to various parts of the mine. This moving about is greatly facilitated because of the spinelike protuberances with which the sides of the body are armed.

Almost all the beetles have emerged from the mines by August 1, and a general migration occurs, the insects scattering far and wide to new fields. After this short period of wandering, they deposit the second lot of eggs of the season, and the resulting beetles appear in early fall and constitute the over-wintering stage. Thus it will be observed that there are two full broods per season.

Nature of work.—On black locust this pest is destructive in both adult and larval stages, but in the main, only the adults are destructive to other hosts. In other words, black locust is the most common plant recorded in which the larvae mine the leaves, though the larvae have been recorded (15) from false indigo (*Amorpha fruticosa*) and from soybean. The adult beetles are foliage feeders, eating irregular holes, and when in sufficient numbers, almost defoliate the trees. Only a partial destruction of the leaf area, however, is sufficient to cause the death of the entire leaf structure, since the unconsumed parts adjoining the mutilations die and turn brown.

In mining the leaves of the black locust, the young larva, after eating through the leaf surface, proceeds to feed on the inner leaf substances, leaving intact the upper and lower surfaces. Rarely are mines found larger in area than a dime. More than one mine may occur in a single leaflet, but one large mine usually is sufficient to cause its death and browning. In instances of severe attacks the combined feeding of larvae and adults may kill the foliage of the entire tree twice in a single season, once in July and again in September. Thus, during some seasons in southern Ohio whole areas of black locust may be browned and appear as if fire-swept. Because of this fact areas of black locust may be detected for miles distant because of their contrast to the surrounding green trees of other species. The year of 1912 will be long remembered in southern Ohio because of this connection, as will also the seasons of 1904 and 1905. In 1907 the locust leaf beetle was reported as being unusually destructive in parts of Pennsylvania, and in 1911 and 1912 locust trees in some areas of Long Island were very severely injured.

During the course of very severe outbreaks, particularly if accompanied by seasons unfavorable to tree development, thousands of locust trees die. Plate XXXII, Fig. 5, illustrates such an area. The attacks invariably are more severe on upland than lowland trees, and the tops of the trees are preferred to the lower branches.

Food plants.—The black locust is the preferred and most severely injured host. However, several instances have come under the observation of the writer in which cultivated apple trees have been attacked violently. Apples are most susceptible to injury if growing in the immediate vicinity of locust groves and when late frosts kill the tender locust foliage after the beetles have emerged. The insects then turn their attention to the apples while the new locust foliage is coming on. During the seasons of 1912-13 apples in the vicinity of Marietta were injured to a considerable extent by the feeding of adult beetles.

Soybeans in southern Ohio were observed in 1912 by E. R. Secrest, of this Station, to be severely injured by beetles.

In addition to the foregoing records, the following hosts either have been observed by the writer or have been reported as attacked by the adult beetles; dogwood, red elm, white elm, oak of various species, beech, wild cherry, Wistaria leaves, hawthorn, red clover, hog peanut (*Falcata comosa*) and raspberry.

Distribution.—The locust leaf miner occurs in greatest abundance in Ohio in the southern part of the State, though it is found sparsely distributed over the other sections. According to other writers the western and southern limit of its range is Missouri and north to and including parts of Canada.

Natural enemies.—Agencies of natural control have much influence in regulating the numbers of this pest. Usually one or two seasons of excessive abundance of the locust leaf beetle are followed by a number of years of comparative scarcity, and it is supposed that the natural enemies of the species are responsible for the sudden reduction of numbers. However, but little is known of these natural control processes.

The young larva of the wheel bug (*Prionidus eristatus*) is reported to feed upon larvae and adults of this species and in addition the following Hymenopterous parasites have been reared, the report of which is extracted from Cotton (Bul. 7, Ohio Dept. Agr.)

"*Trichogramma odontotae* How. Reared from egg masses. In nearly every case where one egg was parasitized, all of the eggs in the mass were similarly attacked. The adult parasite gnaws its way through the leaf, emerging from the upper surface."

"*Derostenus primus* How. A chalcid reared from egg masses, but is thought to be a secondary parasite of *Trichogramma odontota*."

"*Sympiezus uroplatae* How. A hymenopterous parasite, the white larvae of which was found feeding externally upon the larvae of *C.* (O.) *dorsalis*."

"*Spilochalcis odontotae* How. Seen emerging pupa of C. (O.) *dorsalis*. This is an internal parasite.

"*Ichneumon hispa* Harris. Bred from pupa of *C.* (O.) *dorsalis*."

Control.—It is possible to protect plants from injury by this species by spraying with arsenate of lead at the rate of 3 or 4 pounds of the paste or 2 pounds of the powder to 50 gallons of water when the adult beetles are abroad and feeding on the leaf surfaces. The fact that the larvae leave old mines and construct new ones also contributes to the feasibility of spraying with poisons, since some of the leaf surface is consumed when the new mine is started, and in all instances which the writer has observed the entrance to the mine was made on the upper surface of the leaf.

In the spring of 1912 the writer successfully protected apple trees near Marietta by the use of arsenate of lead, but to this was added a small amount of sorghum molasses. The formula used was as follows:

Water	40 gallons
Sorghum molasses	½ gallon
Arsenate of lead	4½ pounds

Laboratory feeding tests confirmed the field results that the beetles could be destroyed by the use of arsenate of lead applications and indicated that slightly weaker strengths could be employed. The molasses undoubtedly contributes to the efficiency of the spray but may not be essential.

Spraying with poisons, however, is practicable only under very limited conditions, such as in the instance cited where valuable fruit trees were to be protected or in the case of prized ornamentals. It is obviously impracticable to attempt a general application of poison where entire hillsides of black locust are attacked; indeed, in such cases there is no practicable control method to use. Clearly it is impossible to clean up the forest floor during the winter and spring with the intention of collecting the hibernating beetles, first, because of the labor involved and, second, because there is a question as to whether the removal of the natural protection and source of fertility might not be quite as harmful as the work of the beetles.

After a scourge of the insect has passed, the resultant injury may be minimized to a certain degree if all trees found to be in a dead or dying condition are utilized promptly. The trees will thus be saved from the horde of insect depredators which feed upon such timber and from the ravages of wood-rotting fungi.

TWO OTHER LEAF MINERS OF THE GENUS CHALEPUS

(*Chalepus nervosa* Panz)
(*Chalepus rubra* Weber)

Quite frequently one finds associated with the locust-leaf miner, the beetles of two other species of the same genus. In general appearance the adults closely resemble those of the better known *C. dorsalis;* both, however, are a little smaller and the general color is paler red. Neither possesses the centrally located black area of the wing covers so pronounced on *C. dorsalis.* Rarely does either *C. nervosa* or *C. rubra* occur in plentiful numbers, though occasionally the first named is fairly abundant. Such an occasion was noted by the writer in 1912 when the insect was observed near Marietta. In this instance dogwood was the favorite host, though locust and apple also were well infested. Only the adults were observed. Basswood is reported as the favorite food plant of the latter; indeed, it is sometimes called the leaf-mining, linden beetle. From the leaves of this tree the mining larvae have been reared. The beetle is also reported as having been reared from the leaves of apple.

Both species are rather widely distributed and both in all likelihood can be controlled by spraying the attacked plants with arsenate of lead.

MAY BEETLES, OR JUNE BUGS

(*Lachnosterna* sp.)

Under some conditions and during some seasons, May beetles, or June bugs, do considerable harm particularly to isolated trees or small groves.

Description.—There are a considerable number of species belonging to this genus (*Lachnosterna*) and they vary considerably in size and appearance. In a general way the adults are heavy-bodied, brown beetles either light or dark in shade. Usually they are about three-eighths to five-eighths of an inch in length, and though heavy and awkward, they fly readily. (See Plate XXXIII, Fig. 1.) The eggs are small white ovals deposited beneath the surface of the soil from one to several inches. The larvae scarcely need description since they are the common white grubs so well

known to all who till the soil. (See Plate XXXIII, Fig. 2.) The pupae are robust with pointed body and folded appendages showing plainly on the underside.

Life history and habits.—The eggs are laid on the roots of plants usually in considerable masses. Upon hatching, the tiny grubs begin feeding upon the plant roots and remain beneath the surface of the soil for a period of 2 years or more. At the end of larval growth they form an earthen cell and transform to the pupal stage. After a variable length of time, the beetles emerge and make their way to the surface of the soil, whereupon they take wing and fly to the treetops to begin feeding. This period of emergence is during May and June, which accounts for the popular name of the insect. Soon after emergence the insects pair and, after a few weeks of existence in the adult stage, during which egg-laying occurs, they die. It will thus be seen that about 3 years' time is required to pass through the various stages from egg to adult.

During the adult stage the insects are nocturnal, spending the day in the grass fields in which they lay their eggs and in the evening flying to their feeding grounds in the treetops. Before morning they return to their grassy retreats.

Nature of work.—The injury caused by these insects is two-fold. The type which occasions the most severe losses is that of the feeding larvae on the roots of plants and upon root crops. Corn and potatoes are more severely injured than other crops, but from the forestry standpoint the injury inflicted upon tree seedlings in nurseries occasionally is serious.

The greatest harm done to trees, however, is the destruction of the foliage by the night raids of the beetles. Not infrequently it is a source of much mystery to the uninitiated when the trees in May and June are seen to be badly mutilated and no trace of a depredator can be found. In severe outbreaks of the beetles, trees may be stripped of their foliage, as frequently happened during the flight of 1914. A glance at Plate XXXIII, Fig. 3, conveys this idea fully. Isolated trees or trees growing in small plots are attacked with greater severity than when otherwise situated; as are also trees growing near rather than distant from grass-lands.

Food plants.—The larvae feed upon the roots of a wide range of plants, and the adults on almost an equally wide range of deciduous trees. Willows and poplars frequently are attacked with great severity as are also elm, oak, ash, etc. Rarely do trees succumb from May-beetle defoliation, but the injury thus sustained detracts from their beauty and usefulness and renders them more likely subjects to injury from subsequent depredators.

Distribution.—May beetles are generally distributed but are more likely to be troublesome in areas abounding in lawns, meadows and pasture lands.

Natural enemies.—Swine, skunks, blackbirds and crows all are well-known enemies of white grub larvae, and the adults are preyed upon by many nocturnal insectivorous creatures.

Moreover, a considerable number of insects are known to parasitize these insects (16).

Control.—From the standpoint of control of the foliage-destroying beetles, which aspect of the problem constitutes the field of the present publication, the cheapest and most effective measure consists in spraying with poisons at the time the beetles swarm to the trees and begin feeding upon the foliage, viz, in May or June. Only occasionally will spraying be necessary for this purpose, but valuable trees should be watched closely during May and June of years when the flights of beetles are anticipated. The foregoing remark applies more directly to the care of country estates, golf links, etc.; in other words, to the care of trees which are particularly valuable and growing in situations which render them most likely to injury from these insects.

In England the countrysides are organized to celebrate "cockchafer" days when huge quantities of the beetles are collected at night by the use of lights, jarring, etc., but such measures scarcely could be said to be practicable under American conditions.

In forest-nursery seedbeds precautions should be taken not to utilize soil known to be infested with white grubs, and clean culture should be practiced that grass and other herbage will not attract the egg-laying beetles and thus cause the beds to become polluted.

THE CATALPA SPHINX
(*Ceratomia catalpae* Bvd.)

Description.—The mutilation and sometimes the complete defoliation of catalpa trees and groves, particularly of the southern part of the State, are traceable to ravages of the catalpa sphinx. In its best-known stage, it is a fleshy caterpillar of the horn-worm group, resembling in size and shape the well-known tomato or tobacco horn-worm. When mature it is about 3 inches long and in common with many other members of the group bears a formidable appearing spine on the rear of the body, which, while fearsome in appearance, is quite harmless. In color the worms are dark green with black markings, but the proportions of the two colors vary greatly, so that a considerable number of patterns are to be

found. There is, however, a distinctly dark and an equally distinctly light form. For an illustration of this and the following stages, see Plate XXXIV.

The pupa is a stocky brown object sharply pointed at one end and found beneath the surface of the soil.

The moth is typical of the group to which it belongs, the *Sphingidae,* with its strong powers of flight, heavy body and altogether neat appearance. It is grayish-brown in color and measures about 3 inches across its expanded wings.

The eggs are pale yellowish-green, ovoid in shape, and are deposited in convex masses on the underside of the leaf. As many as one thousand eggs have been taken in a single mass, though the average mass contains considerably less than that number.

Life history and habits.—The winter is passed in the pupal stage beneath the surface of the soil. After the appearance of the catalpa leaves, the moths emerge and lay their eggs, and the larvae, arising from the masses feed gregariously for some time. Later they separate, but at no time do they lose their ravenous appetite and, during the later stages of larval development, literally mow the foliage from the trees. Upon reaching maturity they pass to the soil, pupate and give rise to the second, or summer brood of moths, which in their turn produce the second brood of caterpillars. The eggs and caterpillars of the second brood are to be found in late July and early August. Seemingly there are but two broods of the insect per year in Ohio.

Nature of work.—The prime injury caused by this insect is the destruction of the foliage of catalpa by the larvae. Some seasons this is very thorough and extensive, occasionally entire plantings suffering a complete loss of their leaves, as indicated by the illustration, Plate XXXV, Fig. 1. City shade trees may be said to be more susceptible to injury than trees growing in the country; and, when the insect appears in the guise of a street-tree pest, another though incidental type of injury appears, viz, the soiling of sidewalks by its castings. In severe outbreaks, and particularly during the later stages of caterpillar growth, this aspect of the situation becomes an important one.

The outbreaks of the pest are variable in intensity and intermittency. It was unusually prevalent during 1905, 1906 and 1907 in some sections of southern Ohio, both as a street and as a forest plantation pest; and during the years following up to the present, scarcely one has passed which has not brought to the office files one or more records of its depredations. A report was received in

1916 from Clifton E. Miller, Summerfield, Noble County, Ohio, in which it was stated that the insect had been prevalent in that vicinity for the three seasons immediately preceding. During the course of the attack, many individual trees had died, and one entire plantation of post timber consisting of 300 to 400 trees had perished. This outbreak was distributed over an area of from 10 to 15 square miles in extent.

Last season (1917) Dr. J. J. Crumley, of the Department of Forestry, Ohio Experiment Station, reported severe damage to *Catalpa kempferii* located on the fair grounds at Athens, Ohio.

Food plants.—So far as is known, the various species of catalpa constitute the sole food plant upon which the larvae of this insect feed.

Distribution.—In Ohio this insect is more prevalent in the southern part of the State; in fact, nearly all the records in Ohio are confined to the area south of a line drawn across the state east and west through Columbus.

In the United States the area of greatest abundance of the catalpa sphinx may be said to be east and south of the Mississippi and Ohio Rivers with the addition of parts of Ohio, Indiana, Illinois and some of the other states bordering this area. It is reported as far north as Manhattan Island. It has been long known in the Gulf states where the larva is esteemed as fish bait.

Natural enemies.—Among the birds four are credited with having appetites particularly keen for this species, these being the Baltimore oriole, the catbird, and the yellow- and black-billed cuckoos.

Of greater significance, however, are several parasitic species of insects which prey upon the caterpillars, one of the most common being *Apanteles congregatus* Say. This species is a cosmopolitan feeder upon the larvae of this group. Another species of great importance is *Apanteles catalpae* Riley. In the case of the two parasites just mentioned, a considerable number may develop within the body of a single larva. Upon reaching maturity the tiny parasitic larvae eat their way through the skin of the host and attach their small snow-white cocoons to the outside of the body, thus causing the larva to appear as if covered with large white eggs. These cocoons in time give forth tiny, wasplike creatures which search out a new caterpillar host, pierce the body with their ovipositors and deposit the egg within.

Tachina fly larvae also parasitize this species.*

*A more extended account of the parasites of this species may be found in U. S. Dept. Agr., Bur. Ent., Cir. 96.

Control.—Two methods of control are available for use, each possessing merits according to conditions.

For the protection of small shade trees, particularly when such are few in number, hand-picking of the conspicuous egg masses from the underside of the leaves, or the collecting of the clusters of young feeding larvae is at once effective, inexpensive and practicable. Even when the larvae become larger and scattered about over the tree, their striking coloration renders them conspicuous and thus fairly easy to find, so that even at that stage hand-picking is not impracticable if the trees are not too large.

The second control measure is spraying with arsenicals. For this purpose arsenate of lead at the usual strength, 3 to 4 pounds to 50 gallons of water, is recommended for application as soon as the caterpillars begin feeding. The spraying method of control is more thoroughly practicable in case of extensive outbreaks in forest plantations or when large trees are attacked.

THE FOREST TENT-CATERPILLAR

(*Malacosoma disstria* Hubn.)

The forest tent-caterpillar has never been recorded as appearing in destructive numbers in Ohio; indeed, the only record in the files of the Ohio Station pertaining to it is that of an egg mass sent in 1904, which the writer identified as this species. However, it has been highly destructive in New York; Illinois has been visited by it, and Ohio likely will be invaded in time.

Description.—The full-grown caterpillar measures nearly 2 inches in length and is sparsely clothed with reddish hairs above, which gradually fade to whitish on the sides. The head is blue and the general color of the body is bluish gray. Extending down the middle of the back is a row of ten or eleven large diamond-shaped or oval spots, one spot to the segment, and directly behind each larger spot is a much smaller one. Extending lengthwise of the body, on each side are two parallel yellowish-white lines. (A cluster of the caterpillars is shown in Plate XXXV, Fig. 2.)

The pupa is formed in a white or yellowish-white cocoon, spun between leaves on the tree, in bark crevices, in trash on the surface of the soil, or in any other convenient shelter. The pupa itself is dark brown. The adults are heavy-bodied, active creatures, the male having a wing expanse of about an inch and the female about 1¾ inches. In color they are buff with a brownish tinge, and the male, aside from size, is further distinguished from the female by the general darker coloration. The eggs are laid in masses encircling the twigs and are covered with a grayish, frothy material.

They vary in number from 100 to 400 in each mass. The ends of the masses are abruptly cut off, thus differing from the apple tent-caterpillar, its nearest relation, the egg mass of which is more oval in outline and with sloping edges.

Life history and habits.—The winter is passed in the larval stage, but within the shelter of the egg shell. Upon the arrival of spring, the larvae emerge and begin feeding, provided foliage is on hand, but if the buds are still closed, await the appearance of the leaves.

All the young of the brood do not appear simultaneously, but there may be as much as a month's difference in the arrival of the earliest and latest oncomers. During the earlier stages of growth, the caterpillars are gregarious, feeding mainly at night or during the cooler portions of the day. At other times they remain clustered and at rest on the foliage of the host or on its trunk or branches. When nearly full grown the larvae become restless and wander about; or in any stage, if the food supply is depleted, they migrate to other plants in true army-worm fashion. In some instances the migrating insects have been reported in such abundance that when crossing railroad tracks the crushed bodies of the caterpillars made the rails so slippery that trains were stalled.

They do not spin a web as the name would signify but feed unprotected on the foliage. They make frequent journeys from the feeding ground to the larger limbs or trunk of the tree and as they pass along leave a slight silken trail. This trail after continued usage becomes well-defined. There is also to be found adhering here and there to the bark of the host, the cast skins of the caterpillars. Usually about 6 weeks are required for larval development, and at the end of this period each insect seeks a shelter to its liking. Some select quarters among the hanging leaves, others in sheltered situations on the trunk and branches, and still others in refuse on the surface of the ground and kindred places. Here the cocoon is spun and the larva transforms to the pupal stage.

The pupal period lasts about 2 weeks, whereupon the adults emerge and pair and oviposition ensues. Since there is but one brood per season, these eggs constitute the over-wintering shelter for the insect.

Nature of work.—The injury caused by the tent-caterpillar is the destruction of the foliage of the host, and in cases of severe outbreaks this may result in not only the defoliation of single trees but the stripping of entire areas. When occuring on street and

shade trees, the presence of great numbers of the obnoxious crawling caterpillars is so repulsive as to be quite intolerable to many persons.

Food plants.—According to Dr. E. P. Felt, the following is the list of food plants of this species: "Linden, maples, locust, peach, plum, cherry, rose, strawberry, apple, sweet gum (*Liquidambar styraciflua*), dogwood, "black gum," sour gum (*Nyssa sylvatica*), ash, elm, black walnut, hickory, walnut, oak, black oak, post oak, white birch, gray birch, willow and poplar." Of the list, sugar maple and oak are the favored hosts, the former suffering tremenduous injury in some of the northeastern states.

The foregoing list suggests that the insect is a very general feeder; and because of this wide range of hosts its wide distribution, as will be shown in the following paragraph, is partly accounted for.

Distribution.—A survey of the literature pertaining to this insect reveals the fact that it has been reported one time or another over nearly every section of the United States; hence Ohio will likely be invaded at some time by an outbreak, particularly since severe scourges have occurred in both New York and southern Illinois.

Natural enemies.—A large list of the caterpillar-destroying birds prey upon the larvae of this species, while to a certain extent the eggs and moths are destroyed by the same agency.

Parasitic Hymenoptera of several species are recorded from the larvae and pupae of this species as are also several Dipterons. Of the former, *Pimpla conquisitor* is mentioned prominently, and of the latter, *Tachina mella* is sometimes abundant.

Of the predaceous beetles, *Calosoma scrutator* Fabr. and *C. wilcoxi* Le. C. are valuable.

Since the forest tent-caterpillar is a native insect, doubtless we should give much credit for the early disappearance of severe outbreaks of it to the natural control agencies.

Control.—Several writers in dealing with this insect place considerable dependence in the plan of collecting the egg masses during the winter. There is some value in this suggestion since most of the egg clusters are found on the lower branches, but in the writer's experience the collecting of egg clusters is rarely satisfactory due to the fact that invariably some are missed and ordinarily the labor involved in the process is so expensive that the method is unprofitable as compared with others which at the same time are more efficient. If egg collecting is depended upon, however, the work should all be finished before the buds break in the spring.

Banding with sticky barriers also is used. Because the caterpillars have a tendency to release all holds and drop to the ground if the tree is sharply jarred, advantage of this peculiarty is taken by some and the trees banded before the caterpillars again find their way to the upper portions. The method is said to possess considerable merit. Tree tanglefoot or materials having similar properties is satisfactory for the banding.

However, the use of the spraying machine with all its modern developments loaded with a non-burning arsenical constitutes under most conditions the most efficient and satisfactory control measure. Arsenate of lead at the normal strength is effective, but as with most leaf-destroying pests, the spray should be applied when the caterpillars begin feeding. As indicated in the life history notes, this occurs in early spring with an expansion of the foliage.

THE OAK TUSSOCK CATERPILLAR
(*Halisidota maculata* Harr)

During the last 2 years the oak tussock moth has been a very common insect in Ohio and much damage in the aggregate has been done; but, due to the fact that the caterpillars feed scatteringly, it has not attracted any great amount of attention. Moreover, our detailed information concerning it is meager.

Description.—The larval form is about the only stage in which the pest is seen with any degree of frequency. When full grown it is about 1¼ inches long, the head being shiny black and the ground color of the body dull black. The body is covered with well-defined short tufts of hair, on some individuals the tufts being white and on others having a decidedly yellowish cast. The short tufts extending in a row down the middle of the back are darker and sometimes almost black. Pairs of slender black tufts almost three times as long as the tufts just discussed arise upward from the upper part of the third thoracic segment and the eighth abdominal segment; a pair of similar tussocks intermingled with black and white extend upward from the second thoracic segment and laterad of the tussocks on the two thoracic segments project white tussocks of slightly inferior length. (See Plate XXXVI, Fig. 1.)

All the legs have a distinct brownish cast. The spiracles are strikingly pure white.

Life history and habits.—So few definite data are known concerning the life cycle and habits of this pest under Ohio conditions that no attempt will be made to enter into a detailed discussion of them. The larvae are most abundant, however, during September, though they sometimes may be observed in considerable quantity in October.

Nature of feeding.—The larvae are foliage destroyers, for the most part feeding singly except, of course, in severe outbreaks when several may be found feeding upon the same leaf. Because of this scattered feeding habit, the damage done is not nearly so noticeable as it would be if concentrated upon one or a few branches.

Food plants.—While occurring in greatest abundance on oaks, this insect may justly be termed a general feeder. The writer has observed it upon the following list of hosts: *Quercus alba, Q. prionus, Q. velutina,* sourwood, ironwood, hazelnut, poison sumac, Juneberry, wild plum, judas tree, *Ulmus fulva,* sugar maple, *Hicoria ovata,* beech and black locust. In addition Doctor Felt reports it upon poplar, willow and alder.

Distribution.—In Ohio this insect is generally distributed, though most abundant in the southern section. According to other records, it is widely distributed through the United States and has been reported from Canada. As the writer has observed it thus far, it is largely a woodland species, and he has never noted it in abundance on street or lawn trees.

Control.—Obviously its present degree of abundance as a woodland pest does not warrant the application of artificial remedial measures. However, since it is a normal, leaf-eating species, in all probability arsenate of lead at the usual strength would control it should the necessity arise.

THE PALE TUSSOCK CATERPILLAR

(*Halisidota tessellaris* Hubn.)

Description.—The pale tussock moth is almost as abundant as the preceding insect and has many points of resemblance in common with it. In size the larva is almost the same, 1¼ inches in length, but the greatest difference is in color. The head is brown and the ground color of the body is grayish-brown with a variable sprinkling of black. Occasionally the black predominates, giving the insect a decidedly dark appearance. The body is clothed with numerous compact tussocks of hairs ranging in color from white to buff. Projecting upward from each of the second and third thoracic segments is a pair of bright tan pencils about three times as long as the hairs of the tussocks on the side of the body, and just beneath each of the four tan pencils is a somewhat shorter white pencil. From the eighth abdominal segment projects a very delicate brown pair of pencils, somewhat shorter than the tan pencils. All the legs are light brown. (See Plate XXXVI, Fig. 2.)

Life history and habits.—The caterpillars are prevalent during September and October. They are isolated feeders and are found on all parts of the host.

Nature of work.—The insects are leaf eaters and, so far as observed, confine their injuries to this field. During the later stages of their growth they devour all parts of the leaf excepting the midribs and when unusually abundant are responsible to a great extent for the practical defoliation of some species of trees. Rarely, however, are they found in pure culture but usually are accompanied by other species of feeding caterpillars.

Food plants.—The pale tussock caterpillar rightly may be termed a general feeder, it having been recorded by Beutenmuller (17) as feeding upon thirty-one plants. According to the writer's observations, sycamore is more commonly and severely attacked than any other species. Not only are small trees of this species attacked but large ones as well, the injury encompassing the upper as well as the lower branches.

Distribution.—This insect is found, according to Packard (18), as far west as the Mississippi River and extends from Canada to Brazil and Paraguay. In Ohio it rarely is harmful as a shade tree pest but occurs in greatest abundance in the hilly woodlands of the southern part of the State.

Natural enemies.—Packard (18) reports that "some of the larvae are infested by Tachinides and numerous species of *Microgaster.*"

Control.—Under present conditions, rarely is it advisable to attempt the utilization of artificial controls. Spraying with arsenicals doubtless would prove efficient if the occasion demanded their use.

THE HICKORY TUSSOCK MOTH

(*Halisidota caryae* Harris)

While not so plentiful in Ohio as either of the foregoing species, the hickory tussock moth has been reported as quite harmful in other sections of the country.

Description.—The adult is a beautiful moth having a wing spread of about 2 inches. The fore wings are beautifully marked by white spots on a light brown background and have the veins lined with darker color. The hind wings are pure white.

The larvae are exceedingly variable in appearance, presenting different markings after each molt. The full-grown caterpillar, however, is 1½ inches long, and has been described by Doctor Harris as follows: "White, covered with white hairs in short spreading tufts, a row of eight black tufts along the back; two long, black, pencil-like tufts on the fourth and tenth segments; four white on the second and third, two in the eleventh and twelfth.

Head, prothoracic legs and surface of the body are covered with minute black tubercles and a transverse black line between each segment. (See Plate XXXVI, Fig. 3.)

Life history and habits.—The eggs are laid in early June on the underside of the leaf in the form of a patch about an inch long, according to Dr. W. E. Britton (19). In Ohio the larvae may be encountered after the fore part of the summer until early fall After first hatching and until they become well developed, they may be found feeding or resting in clusters. Later they become scattered and do considerable wandering, finally pupating in any sheltered place, such as under rubbish, along fences, etc.

Nature of work.—The only type of injury caused by this species is the destruction of foliage by the larva. In Ohio it is not considered a very serious pest, since it rarely occurs in extensive numbers. It is reported as abundant during certain seasons in other parts of the country and should its numbers increase abnormally it is fully capable of much damage.

Food plants.—Thirty-three trees and shrubs, most of which are common, are recorded by Beutenmuller (20) as hosts to this species. Walnut, butternut and sumac seem the preferred hosts, although elm, ash and linden as well as various fruit trees suffer severely.

Distribution.—This insect is widely distributed and is particularly well known in the eastern and northeastern United States.

Control.—Spraying with arsenicals may be practiced where justifiable, and in a limited way the pest may be combated by collecting the clustered, feeding caterpillars or by destroying them when they are massed on the trunk or limbs of the host.

THE VARIABLE OAK LEAF CATERPILLAR
(*Heterocampa manteo* Dbldy.)

Only occasionally does the variable oak leaf caterpillar attract attention by reason of severe and widespread depredations. During the three seasons just passed (1916-17-18), however, it has been excessively abundant in southern Ohio and in some sections has done much damage.

Description.—As the name indicates, the caterpillar is quite variable in appearance. Indeed, caterpillars of this species of the same size are so different in coloration that it is difficult to believe they are the same species. The full-grown larva is about 1¼ inches in length and is very firm and muscular to the touch. A few scattering hairs, more or less rigid in nature, are borne by the body.

The head is beautiful reddish brown with lateral brown or black lines joined at the top to form a horseshoe. These lines are bordered

laterally with white. Extending down the middle of the back is a pale yellow line. The remainder of the body color sometimes predominates greenish yellow, with distinct lighter lines extending along the sides and back, but quite commonly, two broad red-brown lines extend down the back with distinct lateral enlargements on the first, third and eighth abdominal segments. When such a quantity of red-brown coloration is found upon the dorsum, the sides of the body also are generously sprinkled with dots of the same coloration, giving the larva a distinct reddish cast. When the larva is disturbed, a clear liquid appears as tiny drops from pores situated in a line along the sides of its body, whereupon a very offensive odor is noticed. (See Plate XXXVII, Fig. 1.)

The adult moth is a pale ash-gray creature lacking notably distinctive markings and having a wing expanse of nearly 1¾ inches. The pupa likewise is without special characteristics and is a little more than one-half inch in length.*

Life history and habits.—The details of the life history are not known perfectly for Ohio. During the seasons of 1916 and 1917, the larvae were extremely abundant in late September and early October, but whether there had been an early summer brood is not known since the attack was confined to the southern part of the State and no opportunity was had for observations during the early part of the season. Moths appear in the vicinity of Washington, D. C., in late April and early May, according to Comstock (21). He also states that upon completing larval growth in the fall, the caterpillars enter the ground and according to some evidence remain in the larval stage during the greater part of the winter.

Nature of work.—The injury done by the variable oak leaf caterpillar is confined to the destruction of foliage by the caterpillars, which during severe outbreaks may amount to complete defoliation. The insect is sporadic and infrequent in its outbreaks, but a number of cases are on record where great havoc was wrought. It is generally considered a woodland rather than a shade tree pest.

Food plants.—Packard (22) says that the following plants have been recorded as hosts of the species: White, post, burr and laurel oak; hawthorn, basswood, persimmon, walnut, apple, black birch and *Pickneya pubens*.

White oak is more severely injured than any other species in Ohio, in the writer's observation, many trees in the vicinity of Steece, Lawrence County, suffering at least a 50 percent foliage loss

*For a thoroughgoing discussion the reader is referred to Packard's "Bombicine Moths," Natural Academy of Sciences, Vol. VII, pp. 224-230.

during the season of 1917 and a greater loss, approximating 75 percent, during the season of 1916. No cases of complete defoliation were observed.

Distribution.—This insect occasionally is taken in the New England States but occurs in greatest abundance southward and east of the Great Plains States. An outbreak of notable severity was recorded from two counties in Arkansas (21) (1879), in which oaks suffered particularly; another in Texas (23) (1908) to post oaks in particular and still other attacks of considerable severity in Pennsylvania, District of Columbia, Ohio, Virginia and neighboring states.

Natural enemies.—Hooker (23) reports *Calosoma scrutator* abundant and *C. calidum* occasionally present in the Texas outbreak.

Control.—Comstock (21) suggests the burning over of the forest floor at the time the caterpillars are dropping from the trees and entering the leaves, but under Ohio conditions this procedure seems inadvisable; first, because of the actual damage in loss of mulch, burning of trees and destruction of young growth, and, second, because of the danger of spreading fire. Spraying with poisons might be resorted to under exceptional conditions but rarely is it practicable to adopt such measures.

THE YELLOW-STRIPED OAK CATERPILLAR

(*Anisota senatoria* Abb. & Sm.)

During the last decade or more, yellow-striped oak caterpillars have been noted, particularly in the southern part of Ohio, but only during the last 2 years have widespread outbreaks occurred and has severe damage been inflicted.

Description.—The caterpillar is also known as the rosy-striped oak worm, it having been given its popular name because of the eight rosy or yellow lines extending lengthwise of the body on the back and sides. A single row of large yellow spots is found just beneath th. last lateral yellow line and a single yellow line extends the greater part of the body length down the center of the underside. The general ground color of the body is black as is also the head and appendages. The body is abundantly clothed with short, sharp spines, and extending upward from the second thoracic segment are two black, truncate appendages, about three-eighths of an inch long. The full-grown caterpillar measures about 2 inches in length. (See Plate XXXVII, Fig. 2.) The pupa is a dark brown, rough, spined object about 1⅛ inches long and is found in an earthen cell 3 or 4 inches deep in the soil.

The moth is a bright tan insect with its wings irregularly marked with fine dark spots. Near the middle of the front wing is a white spot a little larger than a common pin head. The male is much darker and smaller than the female, measuring only 1½ inches across his expanded wings while the female measures 2½ inches. The eggs measure about four-one hundredths of an inch across and are about half as high as wide. They are round in outline and the shell is very thin. They are laid in masses of from 200 to 500 on the foliage.

Life history and habits.—The moths begin to appear by mid-June and this, together with oviposition, extends over a period of almost a month. Thus, caterpillars of all sizes are found during the summer, but by early fall most of them are mature and pass to the soil. They burrow down 3 or 4 inches where they transform to the pupal stage and in this condition pass the winter.

The caterpillars are somewhat gregarious in their feeding habits, usually defoliating a branch or tree before moving to the next, and occasionally when their food becomes scarce in any given situation may migrate to new plants. Instances are on record where the migrating caterpillars have stopped railway trains. However, if food is plentiful the insect does not spread rapidly and may be found fairly plentiful in a given locality for successive years while in comparatively nearby localities the insect may be unknown.

Nature of work.—The only injury caused by the yellow-striped oak worm is the destruction of foliage by the larvae. Sometimes this is very severe, amounting to total defoliation of large areas of oak woods. To the writer's knowledge such widespread injury has never occurred in Ohio, but during the last 2 years many individual trees in the southern part of the State have been stripped.

Food plants.—In Ohio the writer has observed this insect feeding upon the following hosts: shingle oak, *Quercus imbricoria;* white oak, *Q. alba;* chestnut oak, *Q. prinus;* black oak, *Q. velutina;* scarlet oak, *Q. coccinea;* hickory, maple and hazelnut. In addition to this list, it has been reported on raspberry, white birch, the bear or scrub oak, *Q. ilicifolia*, and the dwarf chinquapin oak, *Q. prinoides.*

Distribution.—This insect is less abundant, according to Felt, in the southern than in the northern section of the United States. In the East the insect extends from Canada to Georgia and has been reported from Wisconsin, Missouri, Kansas and California. It therefore may be said to be generally distributed. Destructive outbreaks have been reported previously from New York, Michigan,

New Jersey and other states. Usually forest trees are the greatest sufferers, although trees in parks, cemeteries, streets and lawns occasionally are severely injured.

Natural enemies.—The caterpillars are unusually tough-skinned, and this, together with the fact that the spines adorning the body are highly operative, renders them partly immune from the more common natural enemies. However, Doctor Felt reports that Prof. A. J. Cook recorded the robin and bluejay as feeding on the larvae. He also reports a Hymenopterous parasite, *Limneria fugitiva* Say, as having been reared from this insect and a young soldier bug, *Podisus placidus* Uhl., as feeding on the eggs.

Control.—When artificial control becomes necessary either of two methods may be employed. If the tree is small and but one or two branches are attacked, the insects may be collected by hand and destroyed. For larger trees over extended areas, spraying with the usual arsenicals is advisable.

THE BROWN ANISOTA
(*Anisota virginiensis* Drury)

Description.—The larva of this species is a beautiful rich, brown-colored caterpillar, the general color being broken by tiny pale yellow raised dots of assorted sizes. The body is further ornamented with numerous, but methodically arranged sharp black spines, the larger and more conspicuous ones being arranged in two rows down the back. On the back of the second body segment are two curved black horns about one-third of an inch in length and having the ends slightly knobbed. At the base, these horns as well as some of the spines, are adorned with tiny, raised, light-yellow dots. (See Plate XXXVII, Fig. 3.) The adult is a beautiful brown, heavy-bodied moth with a conspicuous white spot about twice the size of a large pin head on each fore wing. The female measures about 1½ inches across her expanded wings and the male is considerably smaller.

Life history and habits.—The writer has observed the brown anisota in greatest numbers in late September. In was then in the full-grown larval stage. The larvae feed singly.

Nature of work.—This insect is not a serious depredator in Ohio, at least it has never been reported to the Ohio Station or observed by the writer as occuring in plentiful numbers. The caterpillars are strong feeders and should they occur in abundance are capable of considerable injury.

Food plants.—The writer has observed this species most frequently on hazelnut. He has also taken it upon chestnut, *Quercus minor, Q. alba* and *Q. prinus*.

Distribution.—The brown anisota is found most frequently in this state in woodlands in the southern portion. From the reports of others its range may be given roughly as occupying the greater part of the United States east of the Mississippi River and westward to include parts of Missouri and Minnesota.

Natural enemies.—A Tachina fly and *Limneria fugitiva* Say are parasitic upon the caterpillars.

Control.—The writer has never seen an outbreak where control measures were necessary. Doubtless an application of arsenicals would be effective if the occasion demanded their use.

THE GREEN-STRIPED MAPLE WORM
(*Anisota rubicunda* Fabr.)

Description.—The general appearance of the larva of the green-striped maple worm may be seen in Plate XXXVII, Fig. 4. The full grown caterpillar is a little over 1½ inches in length. Its general color is a pale yellowish-green, striped with darker green. The head is cherry red. As will be seen from the illustrations the body is generously ornamented with spines which are black, and two long, curved spine-like processes extend backwards from the second thoracic segment.

The moth is rose-colored, the fore wings being marked with a broad, pale, yellow cross-band. It measures about 2 inches across its expanded wings.

Life history and habits.—In Ohio the green-striped maple worm is single brooded, the adults being present in greatest numbers in June and the larvae a month or so later. In the central West, the insect is two-brooded, the larvae appearing in June and again in September.

Nature of work.—Occasionally the green-striped oak worm is sufficiently numerous to cause defoliation although this rarely occurs in Ohio. As a rule the larvae feed singly and because of their close color resemblance are rarely seen upon the foliage but attract attention when they fall to the sidewalk or lawn.

Food plants.—Various maples and especially the swamp or red maple are preferred to other hosts, although the insect has been reported upon oak.

Distribution.—The green-striped oak worm occurs throughout Ohio and in many states to the east and west. It is particularly abundant in Missouri and Kansas.

Natural enemies.—*Tachina bifasciata* Fabr. and an Ichneumon fly have been reported as parasitic on this species.

Control.—Spraying with arsenicals is an effective control.

THE VICEROY
(*Basilarchia disippus* Godart)

Description.—The viceroy is best known in the adult stage. It is then a beautiful, brown butterfly having much the appearance of the common milkweed or monarch butterfly. Moreover, it mimics the monarch very closely and this fact combined with its close physical resemblance renders it frequently mis-identified. Upon close inspection the viceroy will be found to be smaller than the monarch and the conspicuous black cross-veins of the hind wing are much differently arranged than with the monarch.

In contrast with the adult form, the larvae of the two hold little resemblance. A glance at Plate XXXVIII, Fig. 1, conveys a better idea of the physical characteristics of the insect than it is possible to do by means of a description. Regarding color, however, it may be stated that in general it is reddish-brown marked with yellow. When full grown it measures nearly 1¼ inches long. (See Plate XXXVIII, Fig. 1.)

Life history and habits.—The winter is passed in the partly-grown larval stage within the shelter of a rolled up leaf. The caterpillars are most abundant in September when they may be found feeding singly on the preferred host.

Nature of work.—The harm done by this species is not extensive simply because the insect rarely occurs in great numbers. It is a foliage-devouring insect, however, and if it should occur in abundance is capable of considerable harm.

Food plants.—In the main the viceroy feeds upon the leaves of willow and poplar, although it has been reported on the plum.

Distribution.—This species occurs throughout the State. Its general range is given by Holland as "everywhere from southern Canada and British America into the Gulf States."

Control.—Spraying with arsenicals is effective where remedial measures are necessary. Handpicking the feeding larvae likewise is practicable in some instances.

THE RED-HUMPED OAK WORM
(*Symmerista albifrons* Abb. & Sm.)

Description.—The larva of the red-humped oak worm merits its common name because of the large red hump on the eighth abdominal-segment, and this, in conjunction with its large red head, renders it a conspicuous caterpillar. (See Plate XXXVIII, Fig. 2.) Five slender black lines on a lilac background extend down the back. of the caterpillar and bordering these on each side in a single broad yellow line. Bordering the yellow lines are three black lines and below these is another yellow line. Except for the enlarged head,

the body gradually increases in size until the hump at the rear is reached and is devoid of all hairy covering. The full-grown larva measures from 1½ to 2 inches in length.

The pupa is moderately stout and blunt and measures about an inch in length. The adult moth measures about 2 inches from tip to tip of its expanded wings. It is light, ashy gray in color with a long white area near the front margin of the front wing.

The pale green, shiny eggs are laid in masses on the underside of the leaves.

Life history and habits.—In June the moths emerge from the over-wintering pupae and deposit their eggs in the masses and position previously indicated. Upon hatching the larvae feed at first in phalanx or at least gregariously but soon they separate and spread over the tree. They reach maturity in late September or early October, migrate to the forest floor and spin their silken cocoons among the leaves near or on the surface of the soil. It follows, therefore, that there is but one brood per season in Ohio. The larvae appear most prominently in late August and September. In the southern states there are said to be two broods per season.

Nature of work.—This is for the most part a forest or woodlot species which damages the host by chewing away the leaves. Since the caterpillar appears rather late and thus destroys the leaves after they have served their greatest usefulness to the tree, its damage is not so severe as if it appeared earlier in the season. Moreover, this insect has never done excessively severe damage in Ohio and may be considered one of the relatively unimportant shade and forest pests of the state.

Food plants.—The writer has observed the pest on white oak only, but other species of oak have been reported as injured, as have also beech and maple.

Distribution.—Other writers give the range of this pest from southeastern Canada south, and southwest to Georgia and Texas and as far westward as Kansas. The eastern United States, however, is perhaps the range of its greatest abundance, although in 1891 a very severe outbreak occurred in Michigan.

Control.—Should this species become sufficiently abundant to demand treatment, doubtless spraying with arsenicals would be effective.

THE RED-HUMPED APPLE WORM

(*Schizura concinna* Sm. & Abb.)

The red-humped apple worm, as its name indicates, is more commonly a fruit tree pest than a shade and forest insect. It is

sometimes plentifully distributed on other than fruit trees, and hence is treated in the present grouping.

Description.—The full-grown caterpillars (see Plate XXXVIII, Fig. 3) measure an inch or more in length. On the fourth segment of the body, also called the first abdominal segment, there is a conspicuous red hump. The head is coral red and the body is marked with black and yellowish to white lines. Black, stout spines in a double row adorn the top of the body and smaller spines are found lower down along the sides.

The pupa is short, stout and a bright glossy brown, occurring in a slight cocoon in trash on the ground.

The adult is an inconspicuous, grayish brown moth, the female having a wing expanse of about 1$\frac{3}{8}$ inches and the male slightly less. The eggs are white, nearly round and are deposited in masses of a hundred or less on the underside of the leaves.

Life history and habits.—The moths appear in June or July and deposit their eggs, and the young upon hatching feed for a time *en masse* upon the underside of the leaves. This gregarious habit is maintained to a certain extent throughout their larval existence but toward the completion of larval growth they become somewhat separated. As the larvae grow larger they at the same time modify their feeding habits, ultimately devouring the entire leaf structure with the exception of the stem and larger midrib. When not feeding, frequently they may be found at rest on the branches or trunk of the host and at that time the rear portion of the body is slightly elevated.

In September the larvae pass to the surface of the soil, construct fragile cocoons among the leaves and trash and there remain until spring. In the spring they transform to pupae and later emerge as moths as indicated previously.

In Ohio there is one brood per season.

Nature of work.—This is solely a foliage-destroying species, which for the most part confines its activities to the farm and forest rather than to city trees.

Food plants.—The writer has taken the red-humped apple worm as a forest pest on willow and butternut. Other writers have reported it upon aspen and *Betula alba*. It has been observed or reported upon apple, cherry, plum, pear and other fruit trees.

Distribution.—This insect is generally distributed, having been reported from Canada to the Gulf and from the Atlantic to the Pacific.

Natural enemies.—Undoubtedly natural agencies do much by way of holding this species in check, but few have been determined definitely. Lounsbury (24) reports a small Ichneumon but does not determine it. Dr. Edith M. Patch (25) reports *Limneria guiguardi* Prov.

Control.—If the attack is slight, involving only a few small trees or a few colonies of the pests, hand collecting and destroying the clusters of feeding larvae is feasible. For more extensive operations arsenical spraying is most practicable.

THE POPLAR LEAF-TYER
(*Melalopha inclusa* Hubn.)

The poplar leaf-tyer is also known by the common name of poplar tent-maker, but the writer prefers the first used since it more perfectly describes the characteristic retreat of the species.

Description.—The poplar leaf-tyer is best known in the larval stage. The mature larva is of stocky build and measures about 1¼ inches in length. The general body color is yellowish brown. On the back of the first thoracic segment are two black, almost contiguous spots, and on the first and eighth abdominal segments are two distinctly-raised black warts. The head and true legs are black as are also three lines extending lengthwise of the back. On the sides of the body are three broader black lines, and the broadest of these is peculiarly marked by numerous irregular curved figures composed of very fine lines. (See Plate XXXVIII, Fig. 4.) The pupa is thick and not quite three-fourths of an inch long. It is formed in a loose web cocoon spun in a folded leaf of the host.

The moth measures a little more than an inch across its expanded wings and is light gray in color. The hind wings are sparsely sprinkled with dark brown scales. The egg is hemispherical and pure white when first laid, later becoming red.

One of the most pronounced characteristics of this species is the peculiar retreat of leaves bound together and lightly lined with silk in which the larvae rest when not feeding. A characteristic specimen is shown in Plate XXXIX, Fig. 1. Sometimes but a few caterpillars will be found in one of these nests while on the other hand the writer has counted as many as thirty-six. The larvae lie with bodies parallel.

When the nest is a large one, the weight of the caterpillars, together with the large quantity of frass which the nest sometimes contains, droops the twig badly. The old nests hang on over winter and, when occurring in areas infested by brown-tail moths, are frequently mistaken during the winter for this much-dreaded species.

Life history and habits.—According to Doctor Garman (26), adults have been secured in Kentucky in March and April as well as in July and August, indicating two broods; since the writer has observed the larvae in large numbers in southern Ohio as late as September and October, undoubtedly two broods occur in Ohio. The winter is spent in the pupa stage. The caterpillars feed gregariously, beginning at first with the under-surface of the leaves but later consuming all portions excepting the petiole and midrib. They do not feed upon the leaves which serve as their shelter; in fact, as a special protection they secure these leaves to the twig by silken bindings.

Nature of work.—Doctor Garman (26) reports the species as destructive to the foliage of street and lawn trees in Kentucky, but under Ohio conditions the writer has never seen it in any role excepting that of appearing occasionally on woodland and roadside trees. Not only do the feeding larvae do bodily harm to the trees when they appear in abundance, but the over-wintering tent remnants detract considerably from the natural beauty of the host.

Food plants.—Various species of poplar, particularly *Populus tremuloides*, and various willows serve as hosts for this species.

Distribution.—The poplar leaf-tyer has been reported from various sections of the United States east of the Mississippi River and as far west as Colorado. Of this area it is more abundant in the eastern portion and in Ohio it is most frequently encountered in the southern part.

Natural enemies.—Doctor Garman (26) says: "The case made by the larvae makes a very comfortable house, swinging in the breezes, sheltering them from the weather, and, perhaps, to some extent, from enemies; but as might be expected of a species, individuals of which live closely crowded together, it is subject to an epidemic disease that sometimes carries off most of the individuals of the second brood. It has some appearance of a bacterial disease, the dead worms quickly becoming limp and discolored, while motile bacteria swarm in their body fluids in doubles of large size.

They are attacked also by a gray fly parasite (*Frontina frenchii*) which emerged from confined lots in some numbers."

Control.—Cutting out and destroying the leafy retreats with their quotas of caterpillars is a simple and effective control measure with small outbreaks. In the event of a widespread outbreak, however, spraying with poisons would be more satisfactory.

ABBOTT'S PINE SAWFLY
(*Lophyrus abbotti* Leach)

Possibly more than one species of sawfly occurs in the State as a pest of pine, but Abbott's pine sawfly is the only one the writer has been able to breed out and determine.

Description.—The larva of this insect when mature is from three-fourths to one inch in length. The general body color is yellowish-white with four rows of almost rectangular black spots extending in lines lengthwise of it. The head also is black. (See Plate XXXIX, Fig. 2.)

Pupation occurs in a rigid, tough, yellowish-white, silken cocoon in the trash at the surface of the soil. The pupa measures about two-fifths of an inch in length.

The adult is described by Felt as follows: "The male has a wing spread of about one-half of an inch and the female two-thirds of an inch. The body of the male is black, exposing the yellowish underside and tip of the abdomen. The female is honey-yellow, with head and thorax a little darker, the thorax with the abdomen being slightly marked with black. The wings are transparent with black veins."

The tiny, white, ovoid egg is inserted in slits in the epidermis of the pine needles.

Life history and habits.—The winter is passed within the shelter of the cocoon, and with the coming of summer the adults commence to emerge. This period of emergence extends over several weeks; hence caterpillars of various sizes may be encountered during the season, particularly since apparently there are two broods per year in Ohio. The eggs are laid in the manner described previously. When disturbed the larvae elevate both ends of the body in a threatening manner, but if the tree or branch is jarred with some severity they fall to the ground. They feed gregariously and when mature spin their cocoons in great numbers in the trash at the base of the host.

Nature of work.—When the insects are plentiful, some slight harm is done the host by the process of oviposition in the leaves, but the principal injury is the destruction of the foliage by the feeding larvae. Since conifers show little tolerance to foliage losses, severe and particularly repeated attacks work great harm to the tree. Sometimes only branches are defoliated, while at other times whole trees, as indicated by Plate XXXIX, Fig. 3, and occasionally entire areas, as reported from New Jersey and elsewhere.

Food plants.—In Ohio the writer has observed this species on pitch pine, *Pinus rigida*, short leaf pine, *P. echinata*, and white pine,

P. strobus. It probably feeds on other species of pine, but in most of the published records concerning it, white pine is mentioned particularly; hence this tree must be the usual and preferred host.

Distribution.—This insect is most prevalent in the eastern and east-central states, but has been reported as far west as Iowa. Under Ohio conditions it is more prone to attack isolated trees than those growing in thick, pure stands, and is a pest of rural rather than city trees. It has been reported and observed in various sections of the State, one of the most destructive outbreaks appearing in the white pine plantings of the Oberlin Waterworks Farm, and reported by A. E. Taylor, of the Department of Forestry of the Ohio Station, October 8, 1915. In this instance it was estimated that 50 percent of the trees were attacked, and of this number 5 percent were defoliated.

Natural enemies.—The writer has bred from the cocoons a Hymenopteron determined by S. A. Rohwer, of the U. S. National Museum, as *Lagrotis diprioni* Rohwer. Cook (27) has reported a chalcid parasite, *Perilampus hyalinus* Say, and Felt (28) reports *Limneria lophyri* Riley.

Control.—Since the larvae feed gregariously, hand picking frequently is practicable but where the infestations are extended, spraying with the arsenate of lead poison is advisable.

THE COTTONWOOD LEAF BEETLE
(*Lina scripta* Fabr.)

The writer has observed the cottonwood leaf beetle but a few times in Ohio; but, because of its destructiveness in other states particularly to basket-willow plantations, it is treated here in a fairly comprehensive manner.

Description.—The adult is a hard-shelled beetle, elongate and rounded in form, and averaging a little less than three-eighths of an inch in length. Beneath, it is dark metallic green. Above, the head and thorax are black, the latter being bordered with dark yellow or red. The wing-covers are gold, marked with three interrupted lines. Great variations exist, however, in the color and markings of the wing covers, as will be seen by a glance at the accompanying Plate XL, Fig. 2, the range extending from almost pure gold to almost unbroken black.

The eggs are light yellow, are almost one-fifteenth of an inch long and are deposited in a slightly slanting position, most frequently on the underside of the leaf.

The larva upon first hatching is about one-twenty-fifth of an inch long and is black or very dark brown. Upon maturity the larva

is about one-third of an inch long. The body is dirty yellowish, the head brown and legs black. In general appearance the larvae resemble those of lady beetles.

The pupae are attached by the tip of the body to the undersurface of leaves, to twigs or to any nearby object. The free part of the body is black and the rear dark brown, the legs, wings, etc., being plainly discernible.

Life history and habits.—The winter is passed in the adult stage in the shelter of grass clumps, beneath stones, logs, bark or any convenient protected situation. From their winter homes the beetles emerge in late April or May, according to Lowe (29), making their appearance in the vicinity of Syracuse, N. Y., from May 1 to 10. Soon the eggs are laid in the manner previously described, hatching in from 10 days to 2 weeks. Usually about 2 weeks is required to complete larval growth.

Drops of white, ill-smelling milky fluid are emitted from tubercles along the sides of the thorax when the insects are disturbed. This evidently serves as a protection against predators. In addition to the power to eject this milky liquid, the insects can also retract it, which they do when the disturbance ceases. Thus if they are alternately disturbed and let alone they will likewise alternately expel and withdraw the drops. At the tip of the larval body is a sticky disc, which not only aids the insect in crawling during the active feeding period but also serves to suspend the body when larval growth is complete and pupation is about to occur. The pupal stage lasts about 2 weeks. It is Doctor Lowe's belief that two and possibly three broods occur in New York State. Early in August the insects seek their winter quarters.

Nature of work.—Both adults and larvae of the cottonwood leaf beetle feed upon the foliage of the host, and in addition the growing tips of basket willow are so seriously mutilated as to cause their death. The dying of the shoots causes branching and bushiness, thus ruining the willows for basket purposes. As a destroyer of the foliage of shade and ornamental trees, this pest is sometimes serious, particularly in the western states where the cottonwood is prized for this purpose.

Food plants.—Various species of *Populus* are attacked by this species, the cottonwood probably being preferred above all others. Many willows also are attacked and of this group of hosts, the Osier or basket willow of Europe, *Salix viminalis,* seems the chosen sort when available.

Distribution.—This species is distributed over nearly the entire United States, occurring in greatest numbers in the western-central section.

Natural enemies.—Lady beetles of several species are known to destroy this insect in the earlier stages and particularly in the egg stage. Species of Ichneumon and Chalcid flies are reported as parasitizing it, while tiger beetles and ground beetles are reported as preying upon it.

Control.—Under Ohio conditions, when control measures become necessary, spraying with arsenate of lead is the cheapest and most effective method. Since the insects feed largely upon the lower side of the leaves and since the leaves of Populus and willows are so glossy that sprays do not adhere readily, the liquid should be directed so as to cover the under leaf surfaces, and soap should be added to the spray solution to facilitate spreading and sticking.

In sections of New York, where basket willows are cultivated, the growers use an ingenious beetle-collecting machine to good effect. The machine is so arranged that when it is drawn or pushed down the rows the beetles and their larvae are collected in a pan filled partly with kerosene and are thus destroyed. This machine is illustrated and described by Doctor Lowe (29). The field of usefulness of this apparatus is very limited, particularly in Ohio, since little is done with the basket-willow enterprise in this State.

THE SPOTTED WILLOW LEAF BEETLE
(*Lina interrupta* Fabr.)

The preceding species seems more abundant than the spotted willow leaf beetle in most states where these pests occur. Under Ohio conditions, however, the latter is more abundant and destructive. In most accounts it is treated under the name of *Lina lapponica* Linn. or *Melasoma lapponica* Linn., but according to Blatchley (30) *lapponica* "is a European speciees with thorax wholly metallic." With our species *interrupta*, as will be seen by an examination of the accompanying illustration, Plate XL, Fig. 1, the thorax is edged laterally with lighter bands.

Description.—The adult beetle resembles closely in size and shape the preceding species, being a little less than three-eighths of an inch in length and of elongate, rounded form. In coloration, however, *interrupta* differs greatly from *scripta*. The present species is deep black beneath showing a slight tinge of metallic. Above the thorax is shiny black with a border of red or yellow at the sides. The wing covers are deep yellow or red, variously marked with black as is shown in Plate XL, Fig. 1. As a rule, the

beetles are much more plentiful which show a generous amount of black on the wing covers. The ground color of the wing covers referred to as deep yellow or red is, under field conditions more frequently yellow than red, although occasionally infested areas are found in which the red form of the beetle predominates. The eggs are deposited in masses of about fifty on the leaves of the host, each egg placed on end. They are greenish yellow, oval and about one-eighth of an inch long. The larva at first is black, later becoming lighter in color, and possesses the same arrangement of warts or spines for the secretion of the white, pungent, milky material as described for the preceding species. Some writers state in comparing the larvae of the two species that they cannot be distinguished apart unless it be that the milk secretion is a little more profuse and pungent in the present than in the preceding. These larvae likewise have the power to expel and retract the secretion. The pupae of the two species are much the same and are found in similar situations.

Life history and habits.—The insects winter over in the adult stage in trash or in any sheltered place. In April they emerge and begin feeding upon buds or foliage, depositing their eggs soon after the leaves appear. The larvae upon hatching feed gregariously and maintain to a certain extent this habit throughout their existence. When mature they pupate after first securing the tip of the body to some convenient surface. Frequently the pupae occur in clusters of a pendent nature on the drooping twig tips of willow, as shown in the illustration, Plate XL, Fig. 3. Since the insects have been observed by the writer to be abroad as early as April 27 in southern Ohio, there are in all likelihood two broods per season and probably more, regardless of the fact that the adults are known to select their winter quarters as early as the latter part of August.

Nature of work.—Both larvae and adults are foliage eaters and the adults sometimes do much harm by eating out the developing spring buds before the foliage starts. This type of injury was observed April 27, 1916, at Rock Bridge, Ohio, where alder buds were quite destroyed. Sometimes many as four or five beetles were observed feeding upon a single bud. Similar injury to willows at Wooster was observed May 5, 1916.

The injury inflicted by the feeding insects in early summer is quite extended in some sections of the State. For several years past the willows about Wooster have been attacked in a serious manner, as indicated by Plate XL, Fig. 4. Usually the lower grow-

ing willows are attacked most severely but not infrequently both large and small appear as if swept by fire even as early in the season as June 8.

Food plants.—The chief food plants of the spotted willow leaf beetle in Ohio are the various species of native willow. In addition to these, the writer has observed it on cottonwood and alder. Doctor Garman (26) states that willow nursery stock in Kentucky is sometimes seriously injured.

Distribution.—This insect occurs in all parts of Ohio. In other parts of the country, it is reported to occur from Massachusetts southward and as far west as Nebraska. In the latter state it has long been listed as one of the enemies of cultivated poplars.

Natural enemies.—The natural controls of this species have not been carefully studied. Harned (31) reports having seen lady beetles on the leaves with the eggs and young larvae. It is likely, particularly since these insects are known definitely to prey upon the preceding species, that they attack this one as well.

Control.—When artificial control measures become necessary, undoubtedly the most practicable is spraying with arsenicals. The poison should be used in early spring at normal strengths; and, since willow leaves are glossy and repel liquids, soap as a spreader and sticker should be added to the spraying liquid.

THE HICKORY HORNED-DEVIL OR REGAL WALNUT CATERPILLAR
(*Citheronia regalis* Fabr.)

While *Citheronia regalis* has not been recorded as being sufficiently plentiful to do damage in Ohio it is the cause of frequent inquiry because of the formidable appearance of the larva, and for this reason is considered here.

Description.—The larva is the largest caterpillar occurring in Ohio, when full-grown measuring as much as 5 inches in length and almost three-fourths of an inch in thickness. The head is yellow and the body a dark yellowish-green, the four pairs of abdominal legs being almost black. The body is armed with spined horns, most of the segments having on them four or more short black horns arranged in a row around the body, but on both second and third thoracic segments of the body are four large horns yellow at the base and black at the tip. They are curved backward like a goat's horns, and because of this resemblance the caterpillar is sometimes known as the billy-goat caterpillar. A good idea of the general appearance of the insect in this stage may be had from Plate XLI, Fig. 1. It will be observed that the insect presents a strikingly formidable aspect, and, this together with the fact that

it throws the forepart of the body from side to side when disturbed, makes it greatly feared by many. It is a harmless creature. However, if in handling it one carelessly squeezes it or by any means pierces the flesh with the spines, the wound is rather painful.

The pupa is of stocky build and is about 2¼ inches long. It is a beautiful brown and occurs beneath the surface of the soil.

The adult is one of our most beautiful moths. It has a wing expanse of about 6 inches. Its color is described by Felt as "reddish brown with bright, brick-red markings."

The egg is almost one-eighth of an inch in length, oval with thin flexible shell and covered with fine pits.

Life history and habits.—Apparently the winter is passed in the pupal stage beneath the surface of the soil. Riley states the moths emerge in the latitude of St. Louis, usually during the last half of June. In Ohio the writer has taken the mature larvae in considerable abundance in late September and early October. Moderate frosts do not stop the feeding of the insects. It is probable that the insect is only one-brooded as far north as Ohio but Packard (18) reports it as double-brooded in Georgia.

Nature of work.—This is solely a foliage-destroying species, and on account of the tremendous size and voracious appetite of the larvae would consummate great injury were it to occur in great numbers. Fortunately it is not an abundant species and the feeding of a few larvae is not of great moment.

Food plants.—Black walnut, butternut, hickory, persimmon, sumac, sweet-gum, sycamore, ash, lilac, cotton, sea-island cotton and sassafras are listed as food plants. During the last two seasons the larva was found with considerable frequency upon the last-named host in southern Ohio during late September and early October.

Distribution.—The hickory horned-devil is found over a territory extending from the southern New England states to as far south and west as Texas. Its range of greatest abundance is probably the eastern-central states.

Natural enemies.—Packard (32) reports a large species of Tachina, *Belvosia bifasciata*, as bred from this species.

Control.—The writer has never heard of an instance where artificial control measures were necessary. However, should the necessity arise, hand picking the larvae or spraying with arsenicals doubtless would prove effective.

THE IMPERIAL MOTH
(*Basiloma imperialis* Drury)

The imperial moth is a little more abundant than the preceding species. It, too, is given consideration in the present bulletin not so much on account of its economic importance but because of the interest attracted by the striking appearance of the larva.

Description.—The full-grown larva has been described by Dr. T. W. Harris as follows: "They are from 3 to 4 inches in length and more than one-half of an inch in diameter, and, for the most part of a green color, slightly tinged with red on the back; but many of them become more or less tanned or swarthy and are sometimes found entirely brown. There are a few very short hairs thinly scattered over the body; the head and legs are pale orange colored; the oval spiracles, or breathing holes, on the sides, are large and white, encircled with green; on each of the rings, except the first there are six thorny knobs or hard and pointed warts of a yellow color, covered with short black prickles; the two uppermost of these warts on the top of the second and third rings are a quarter of an inch or more in length, curved backward like horns, and are of a deeper yellow color than the rest; the three triangular pieces on the posterior extremity of the body are brown, with yellow margins and are covered with raised orange-colored dots."

In the writer's observations, the brown and green forms were almost equally abundant, and during the course of the study an attempt was made to correlate the color forms with certain food plants. After 2 years' observation, however, his data did not indicate that the kind of food had any bearing upon the coloration of the larva. An idea of the general appearance of the larva may be had by referring to Plate XLI, Fig. 2.

The pupa is dark brown, about 1½ inches long and is found beneath the surface of the soil.

The adult is a very beautiful moth. The fore wings are yellow with pale lilac lines and areas. The hind wings are yellow also, with a somewhat less amount of the lilac markings.

The eggs are nearly one-eighth of an inch long, white and somewhat flattened with a distinct equatorical ridge.

Life history and habits.—The winter is passed as a pupa, the moths emerging in June and depositing eggs. The caterpillars hatch and mature in late September or early October. They then pass to the ground and construct their over-wintering cells. So far as known, never more than one brood develops in Ohio per season.

Nature of work.—Destruction of foliage by the feeding caterpillars is the only type of injury done by this species. Since the larvae are never abundant, the actual harm done is negligible.

Food plants.—Doctor Felt (28) states that fifty-two species representing fifteen natural orders are recorded as hosts. Packard (32) records the following list of hosts: "Oak, button-wood, basswood, maple, honey locust, wild cherry, sweet gum, sassafras, elm, sycamore, beech, chestnut, elder, horn beam, birch, alder, white pine, spruce, cedar, cypress and juniper." The writer can add to the list *Pinus echinata* and red maple.

Distribution.—The range of this insect in North America extends over most of the eastern half of the United States and into parts of Mexico.

Control.—Collecting the larvae or spraying with arsenicals are practicable measures in case artificial control becomes necessary.

THE CECROPIA MOTH

(*Samia cecropia* Linn)

Description.—The cecropia moth is our largest native silkworm moth. It is most frequently noted in the chrysalid stage, the large brown-gray over-wintering cocoons attracting one's attention to it. Frequently these cocoons are as much as 3½ inches long. The moth has a wing expanse of between 6 and 7 inches and is marked with various shades of red and tan. The larva is in the main blue in color, with red, blue and yellow blunt tubercles along the back. When full grown it frequently is as much as 4 inches in length. (See Plate XLII, Fig. 1.)

Life history.—The winter is passed by the pupa within the shelter of the cocoon and the adults emerge in early summer and the eggs are deposited. The caterpillars require the greater part of the summer to mature, finally spinning their cocoons on the branches of the host. Since the moths fly at night, rarely does one see the insect in this stage unless it is attracted to the light or unless it is bred from the cocoon.

Nature of work.—The feeding caterpillars have been reported as injurious to nursery stock, and sometimes young trees are almost defoliated. In the vicinity of Toledo, larger trees occasionally are injured severely, the over-wintering cocoons occurring in great abundance. As a rule, however, this species is not considered of great economic importance.

Food plants.—Doctor Felt states that fifty plants representing twenty genera are subject to attack by this species, the more important being "linden, maples, apple and pear, cherry, elm, birch, alder, willow and poplar."

Distribution.—The insect is known to occur throughout the Atlantic seaboard and extends to the West as far as the Great Plains.

Natural enemies.—Doctor Riley (34) reports the following list of parasites of this species: *Ophion macrurum* Linn, *Exorista leucaniae*, Kirk var. *cecropae* Riley, *Chalcis mariae* Riley and *Cryptus extramatis* Cresson. In Ohio, woodpeckers are active enemies of the species during the winter months, piercing the cocoon and drawing out the pupal juices.

Control.—Rarely is artificial control necessary. The simplest method is picking off the large feeding caterpillars. Arsenical sprays doubtless would also prove effective.

THE POLYPHEMUS MOTH
(*Telea polyphemus* Cramer)

Description.—Another member of the large silkworm group is the polyphemus moth, known as the American silkworm because of its particularly heavy silken cocoon. While numerous attempts have been made to utilize the silk, none have proved commercially successful. The moth measures more than 5 inches across its spread wings. In color it is a beautiful light brown with a purplish band near the outer margin of the wings and both fore and hind wings bear large eyelike spots. The eggs are round, flat and light brown, with a band of darker brown around the outer margin.

The larva is a little less than 4 inches long, stocky in build and thicker in the middle. In color it is a beautiful pea green with brown head and with silvery-white ornamentations on the sides. (See Plate XLII, Fig. 4.)

The cocoon is dense, firm and usually with a leaf surrounding it and securely cemented to the outer surface. The pupa within is dark brown and not much longer than thick.

Life history and habits.—The winter is passed in the cocoon and the moths emerge in June to lay their eggs. The caterpillars mature in August or September, spin up their winter cocoons and transform to the pupal stage.

Nature of work.—The feeding of the larvae is the only injury done by this species, and while they possess tremendous appetites and are quite capable of much injury if abundant, they rarely do serious harm since they usually are very scattering.

Food plants.—The polyphemus caterpillars attack a considerable number of trees, some of the more important being white oak, scarlet oak, red oak, sycamore, soft maple, hickory, black walnut,

chestnut, elms, poplars, willows, birches, witch hazel, linden, hazelnut and others. In the vicinity of Wooster it is more commonly found on maple and oak than other hosts.

Distribution.—This insect ranges across the entire continent and into Mexico on the south, according to Holland.

Natural enemies.—Riley (34) states that the following insects are parasitic on the polyphemus moth: *Ophion macrurum* Linn, *Chalcis mariae* Riley and *Tachina* sp.

Control.—Control measures rarely are necessary except in the case of newly-set, valuable trees, when hand picking is practicable and effective.

THE LUNA MOTH
(*Tropea luna* Linn)

Description.—The most gorgeous moth in Ohio is the luna moth. It measures more than 4 inches across its expanded wings, and on the back wings are two long swallowtail appendages. The color is a delicate pale green, the fore wings being margined on the front with a strong band of lavender. On both the fore and the hind wings are prominently marked spots, those on the fore wings appearing somewhat like half-moons and those on the hind wings somewhat like full moons. It is because of this resemblance that the insect is given its name. The larva is about 3 inches long, stout in build and pale green in color. Adorning the body are six rows of small pink tubercles, each with one or more black hairs springing from it. (See Plate XLII, Fig. 2.)

The cocoon is spun among the leaves, is thin and papery. It does not adhere permanently to the tree but falls to the ground in autumn.

Life history and habits.—The seasonal development is quite like that of the preceding species.

Nature of work.—The larvae are leaf feeders but never abundant.

Food plants.—Doctor Felt records the species feeding on walnut, oak, hickory, chestnut, butternut, sweet gum, birch, willow, beech, plum and ironwood. Doctor Holland (33) states it is quite fond of persimmon.

Distribution.—Doctor Holland gives the range of this species "from Canada to Florida and westward to Texas and the trans-Mississippi states as far as the region of the Great Plains."

THE PROMETHIA MOTH
(*Callosamia promethia* Drury)

Description.—The promethia moth also is one of the large caterpillars of the silkworm group and is much more abundant than

the preceding species. The larva when full grown is a little more than 2 inches in length, bluish green in color with two coral-red tubercles on each of the second and third body segments, and a single yellow tubercle on the next to the last segment. The body is also decorated with numerous small, blue-black, slightly-raised tubercles. (See Plate XLII, Fig. 3.) The pupa is firm and is found within a compact, leathery cocoon spun within a rolled leaf. The leaf petiole is covered with silk which extends around the twig, thus firmly securing it. These dangling objects are quite conspicuous during the winter and spring particularly after one learns to detect them.

The moth has a wing expanse of a little more than 3 inches. As is not uncommon among insects, the males and females are strikingly different in appearance. The female with its rich red-brown coloration resembles in many respects the cecropia moth, but the male is decidedly darker, sometimes almost black. The eggs are pale cream in color and are laid in masses of a few eggs each on the twigs of the host.

Life history and habits.—After spending the winter as a chrysalids in the swinging cocoons, the adults emerge in June and pair and the eggs are laid. Most of the summer is required for larval development and the cocoons are spun in late summer or early fall.

Nature of work.—The feeding larvae of this species are sometimes sufficiently plentiful to do considerable harm, occasionally defoliating small trees.

Food plants.—In Ohio this insect is most frequently found on wild cherry and sassafras. In southern Ohio the writer has observed it feeding on tulip poplar, both in natural woodlands and in forest plantations. It is also known to occur on ash, sweet gum, spice bush, maple, plum, poplar, azalea, *Cephalanthus,* snowdrop tree, barberry, birch, bayberry and lilac.

Distribution.—Doctor Holland (33) gives the range of this species "over the Atlantic States from Florida to New England and southern Canada, and thence westward through the valley of the Mississippi to the eastern boundaries of the great plains."

Natural enemies.—Doctor Riley (34) gives the following as the list of parasites of this species: *Cryptus nuncius* Say, *Chalcis mariae* Riley, *Ophion* sp., an Ichneumon and a Tachinid.

Control.—Spraying with arsenicals or collecting the overwintering cocoons are effective measures in controlling this species when it becomes troublesome.

THE IO MOTH
(*Automeris io* Fab.)

Description.—While not an abundant species, the Io moth merits a short discussion because of the attention it draws in both adult and larval stages. The adults are conspicuous because of the large, black, eyelike spots on the hind wings and the larvae because they are covered with numerous branched spines, which on account of their poisonous nature inflict a very severe wound when the caterpillar brushes against one's flesh. The spines are so sharp that they readily pierce the thick epidermis on the inside of the hand of the unwary who unwittingly picks up the wriggling caterpillar.

The moth varies considerably in the sexes, the male being smaller and more brilliantly hued. Riley describes the two by stating the male is "of a deep yellow, marked.... with purple brown, the body and hind wings being of a deeper ochre-yellow. In the female, the purple-brown color predominates and she is somewhat differently marked." Both sexes bear a very striking, large circular eyelike spot on the hind wing. The male measures about 2¼ inches across his expanded wings and the female about 3 inches. A good idea of the appearance of the adult may be had by referring to Plate XLIII, Fig. 2.

An egg of the Io moth is described as top-shaped and attached to the leaf by the smaller end. The color is cream white with a small black spot on the apical end and a larger orange one on the compressed sides.

The full-grown larva is about 2 inches in length, and of a somewhat robust form. The general color is pale green with a narrow lilac line extending along the side of the body bordered below with one of creamy white. Thickly covering the body are black-pointed, delicate green spines. These, as indicated previously, cause a very painful wound when brought in contact with the human skin.

The dark brown pupa is about 1 inch long, broad in front and abruptly sloping to the rear. It is found within the shelter of a few leaves loosely drawn together and further protected by a thin, gummy, silk cocoon. Usually the cocoon is constructed near the surface of the ground.

Life history and habits.—Several writers have recorded the fact that in this latitude scattering adults occasionally appear in the fall but whether they hibernate as such, perish, or deposit eggs which pass the winter is not known. It is known, however, that the greater number of the insects remain over winter as pupae, the

moths emerging in the spring or early summer. About 2 months is required for larval development and in this latitude there is but one seasonal brood. The eggs are deposited in masses of two or three dozen upon the foliage of the host and the caterpillars are semigregarious.

Nature of work.—For the most part the injury by this species is confined to the destruction of foliage by the caterpillars. Only in exceptional instances is this sufficiently severe to merit the adoption of artificial control measures but occasionally such are expedient. In addition to the foregoing, the caterpillars are injurious because of their stinging propensities as mentioned previously.

Food plants.—The Io moth larva feeds upon a large number of trees and shrubs and occasionally attacks cultivated annuals. The following list embraces the plants more commonly attacked: maple, black locust, oak, wild cherry, willows, poplars, beech, sassafras, ash, birch, sycamore, hickory, judas tree and elm. Corn and cotton also have been reported.

Distribution.—This species occurs throughout the eastern United States and Mexico.

Natural enemies.—*Campoplex fugitivis* Say, *Ophion macrurum* Linn. and *Microgaster* sp. are reported as parasitic on the Io moth.

Control.—In some cases hand picking of the larvae is practicable, while in others spraying with arsenicals is best. Usually, however, artificial control measures are not necessary.

THE MOURNING CLOAK BUTTERFLY
(*Euvanessa antiopa* Linn)

Description.—The mourning cloak butterfly is also known commonly as the spiny elm caterpillar. Both common names are very fitting for the stage each indicates.

The adult is our earliest butterfly to appear in the spring. It measures about 3 inches across its spread wings. In color it is very dark maroon—almost black and the wings are bordered with a yellow though sometimes almost white band. Near this band will be observed also a number of blue spots. The eggs are ribbed and are deposited in bands on the twigs sometimes numbering as many as 300 to 400 in a single band. At first they are yellow, then red and finally black.

The caterpillar when full grown is about 2 inches in length. It is black in color, but the black is so abundantly sprinkled with small white dots that the insect has a decidedly grayish cast. A row of red spots extends down the back and each body segment bears several large branched spines. The spines, while formidable

in appearance, are in reality almost harmless. A cluster of the caterpillars is shown in Plate XLIII, Fig. 1. The pupa is about an inch long, purplish-gray in color and is suspended by the rear part of the body.

Life history and habits.—The insect passes the winter in the adult stage within the shelter of a hollow tree or some other convenient place. With the first warm days of spring the butterflies emerge and may be seen flying about woody places. After the appearance of the foliage the eggs are deposited and the young caterpillars soon hatch and begin feeding. They are highly gregarious, spinning a slight silken thread as they feed. When nearly mature they lose their gregarious habits to a certain extent; nevertheless it is maintained sufficiently to designate as one of the characteristics of the species that of defoliating branches and parts of trees rather than generally distributed injury over the whole tree.

Pupation occurs after the caterpillar has suspended itself from some nearby object. There are at least two broods per season and perhaps a third. The insects and particularly the caterpillars are much more prevalent during early and midsummer than during late summer and fall.

Nature of work.—This is both a woodland and city-dwelling species sometimes reaching sufficient numbers to be classed as a serious pest. While no such instance has come under the observation of the writer, several have been reported from New York and New England. However, instances of partial defoliation by the larvae are not uncommon in this State.

Food plants.—While elm and willow are the preferred food plants the insect has been observed upon poplars, birch, hackberry and linden.

Distribution.—This species, according to Doctor Britton, is distributed throughout the temperate regions of the globe.

Natural enemies.—According to Doctor Felt (28) the following natural agencies prey upon this species: Chalcids: *Telenomus graptae* How., *Pteromalus fuscipes* Prov., *P. vanessae* How., *P. puparum* Linn. and *Derostenus antiopae* Pack. Coleoptera: *Calosoma scrutator* Fabr. Pentatomids: *Apateticus placidus* Uhler and *A. serieventris* Uhler. Birds: black and yellow-billed cuckoos.

Several species of Ichneumons are reported from Europe.

In addition to the foregoing, Viereck et. al. (35) report *Hoplismenus morulus* Say and *Pteromalus puparum* var. *vanessae* Harris.

Control.—Collecting the clusters of feeding caterpillars or spraying with arsenicals are the approved control measures when such are required.

THE GIPSY MOTH
(*Porthetria dispar* Linn)

It seems almost superfluous to state that the gipsy moth is one of the two imported caterpillar pests against which the United States Government and various state and local organizations of the East have been waging such heroic efforts during the last few years.

Europe is the original home of the species, but it was inadvertently introduced in this country about 1869 by Prof. Leopold Trouvelot, a French naturalist living at Medford, Mass., who was conducting some experiments in silk culture. During the course of the work some of the caterpillars escaped, and from this start the insect has become established in all the New England States and some adjoining territory.

Egg clusters of this insect were found in the spring of 1914 on stone shipped from the East to Bratenahl, Ohio, a suburb of Cleveland. After its arrival, the stone had been built into a wall and many of the egg clusters had become broken and scattered so that every opportunity existed for the pest becoming established. Through the prompt and effective service of the State Bureau of Horticulture, the Bureau of Entomology of the United States Department of Agriculture, the residents of Bratenahl, and the Forestry Department of Cleveland, it seems that the pest did not become established, since nothing has been seen of it in any stage since the discovery and destruction of the egg clusters 4 years ago. Other introductions might be made in time, and it is with the hope that the pest may be recognized promptly and handled with similar dispatch that the following account is given in considerable detail and the illustrations in natural colors are used.

Description.—The reader is at once referred to Plate XLIV for a general idea of the appearance of the different stages of this pest.

The male moth is much smaller than the female and vastly different in appearance. It has a slender body, is olive brown in color marked with black and has a wing expanse of about 1½ inches.

The female is heavy-bodied, light cream in color with delicate black markings and measures a little more than 2 inches across her expanded wings.

The eggs are nearly round, are light yellow and are deposited in lots of a few hundred to a thousand each in flat, round or oblong

masses and the whole is covered with the buff scales from the underside of the insect's body. The mass so covered is aptly described by Doctor Felt as closely resembling a small sponge.

The caterpillar when first hatched is about one-tenth of an inch in length and heavily covered with brownish-yellow hair. The full-grown caterpillar is from 2 to 2½ inches in length, grayish-brown in color with four rows of prominent blue and red tubercles extending lengthwise of the body. Further adorning the body are numerous well-defined tussocks of black and light yellow hairs.

The pupa is rich brown in color, and varies from three-fourths of an inch to 1½ inches in length. It is sparsely decorated with tawny hairs and is usually suspended by a few silken threads to which it is secured by the hooks at the tip of the abdomen.

Life history and habits.—The winter is passed in the egg stage in the masses previously described. The greater part of the larvae hatch during late April and early May, and the main part of the caterpillar brood matures by early July. The caterpillars feed mainly during the nighttime, remaining clustered on the tree or secreted in hollows and the like, during the day. The early part of July is spent in the pupal stage, the moths appearing about mid-July to deposit their quota of over-wintering eggs. The males fly readily, but the females, while having perfect wings, are unable to fly.

How the insect spreads.—Burgess (36) in his exhaustive discussion of the spread of the gipsy moth calls attention to several methods by which the pest is disseminated, the more important of which are as follows:

A close examination of the very young larvae of the gipsy moth reveals the fact that the insect is clothed with two types of hairs; the normal slender type and others which have an enlarged bulb near the base. Still further seeking shows these bulbs to be nothing other than miniature balloons. Because of their great number, the body of the caterpillar is rendered quite buoyant and easily carried by the wind; hence the floating young caterpillars constitute one of the chief means by which the species is spread. Under the most favorable conditions the caterpillars can float long distances, it having been proved that they can travel in this manner as far as 20 miles.

Another important means of dispersal is the transporting of the insect chiefly in the egg or larvae stage. Since the eggs are laid upon a wide range of objects, such as board piles, packing cases, fencing, stone and other building materials, which are likely to be shipped during the winter from point to point, abundant apportunity

exists for the establishment of new colonies. The experience at Bratenahl is a striking example of the grave danger from this source.

Moreover, since automobile traffic is very heavy through New England during June and July when the caterpillars are abundant, this offers an excellent opportunity for the larvae to become widely scattered. Floating driftwood likewise offers excellent opportunities for the transfer of the insect to points down stream from the infested woodlands, particularly of egg masses. Other means of dispersal are by birds, in the clothing and effects of travelers and campers, etc., but by far the most important means are by wind transference and by the winter shipment of outdoor objects, such as lumber, stone fencing and other rough materials upon which the eggs may have been deposited.

Nature of work.—The harm done by the gipsy moth in the main consists in the destruction of the foliage by feeding larvae, but in severe infestations an incidental effect consists in discomfort caused by the caterpillars invading dwellings and in the unsightliness produced by the adults depositing their eggs on porches, garden-furniture, etc. In severe infestations where artificial control measures are not used, the continued seasonal outbreaks of the caterpillar cause the death of nearly all tree and shrub growth. Thousands of acres of woodland have been destroyed in this way in New England. A glance at Plate XLVI, Figs. 1 and 2 conveys the impression better than words.

Food plants.—The gipsy moth caterpillars can subsist upon practically every shrub and tree native to this country and in addition, may under stress attack herbaceous plants. Forbush and Fernald (37) record more than 500 plants known to be eaten by this species, and it is because of this cosmopolitan taste that the gipsy moth is able to survive such a variety of conditions and to maintain its high standing in the list of noxious pests. A decided preference is shown for certain groups of plants and of the chosen sorts, the oaks may be named first.

Distribution.—In Europe this insect is widely distributed, but in America its distribution is limited in the main to the New England states and nearby parts of Canada. Isolated outbreaks have occurred in other parts of the eastern and east-central United States. Fortunately due to the combined activity of the Federal Bureau of Entomology and the authorities of the states involved, these outbreaks have been subdued; and it is to be hoped that nothing will transpire to interfere with the admirable and efficient services these organizations are rendering.

Natural enemies.—Natural control agencies for the most part hold this insect in check in Europe, but with its introduction into America, these native foes were left behind and this fact accounts for the frightful damage it has been able to inflict. For some years the Bureau of Entomology of the United States Department of Agriculture has been conducting an extensive and thorough-going campaign for the introduction of these European insects, and the work has been crowned with a satisfactory measure of success. A comprehensive report upon the work was published in 1911 by Howard and Fisk (38). In this publication not only is a report made upon the work of importations and colonization but a comprehensive discussion is included concerning the known parasites of this as well as the brown-tail moth. The list of parasites is so long that the writer will not attempt to enumerate them, let alone to discuss each, but will refer the reader to the publication cited.

Control.—The effective control of outbreaks of the gipsy moth depends largely upon the early recognition of the species. The reader who is not familiar with the pest in its different stages again is referred to the illustrations of Plate XLIV. The writer suggests that, whenever material is found of which the identity is not positively known, specimens be submitted to a competent entomologist. If the plan as suggested is followed, outbreaks will be located in their incipiency and the possibility of eradicating the colony greatly enhanced.

In handling small outbreaks the collection or destruction of the over-wintering egg masses is one of the principal methods employed. This is supplemented by banding the trees of the area with a sticky substance, such as tanglefoot, or with bands of burlap. The object in the banding is to collect the caterpillars or moths. A still further aid is spraying with arsenicals after the foliage is well developed in the spring in order to destroy the newly-hatched caterpillars. Since the insect is one of the more resistant to the action of poisons the dosage must be somewhat heavier than usual, from 10 to 12 pounds of aresnate of lead paste being the usual amount used for 100 gallons of water.

In extensive operations, one of the more useful methods is the destruction of the favored hosts where practicable. The larger caterpillars feed with avidity upon conifers but the smaller caterpillars cannot subsist upon these hosts; hence one of the methods of protecting conifers is to develop pure stands of them either by planting or by cutting out susceptible deciduous species.

THE BROWN-TAIL MOTH

(*Euproctis chrysorrhoea* Linn)

Somewhat more than a quarter of a century after the introduction of the gipsy moth into the United States, another and more serious pest was imported from Europe. The brown-tail moth became established at Somerville, Mass., in 1897, and while it has not been in this country more than half as long it now occupies a considerably larger territory than the gipsy moth.

At the same time, by reason of facts which will be brought out later, it is a much more undesirable resident. Thus far it has not been introduced into Ohio, but the people of the State are indebted for this fact to the efficient State Bureau of Horticulture, since on several occasions the over-wintering form has been taken on plants shipped in.

Description.—The name "brown-tail moth" aptly describes the adult of this species since the insect is pure, lustrous, satiny-white with the abdomen tipped with a conspicuous reddish-brown tuft. Sometimes, however, there are a few black spots on the fore wings. The white antennae are fringed with light brown hairs and the veins of the wings show a slight light brown tinge.

The female measures 1¾ inches across her expanded wings and the male 1½ inches. For a good illustration of the insect in its various stages the reader is referred to Plate XLV. The yellow, globular eggs are deposited in compact masses of from 200 to 300 on the underside of a leaf. Each mass is about three-fourths of an inch in length and is covered with the brown hairs from the tip of the abdomen of the female moth.

The full-grown caterpillar ranges from 1 to 1½ inches in length. The body color is very dark brown to almost black and is clothed with tufts of barbed poisonous hairs arranged on tubercles. Most of the tubercles bear brown hairs, but rows on each side of the body have some white ones, and a coral red tuft appears on each of the tenth and eleventh segments.

The pupa is about five-eighths of an inch in length, dark brown in color and is found in a loosely-woven cocoon in any convenient crevice or shelter.

Life history and habits.—The winter is passed in the partly-grown larval condition within the shelter of a few leaves drawn together by a silken web. These over-wintering webs in some respects closely resemble the larval retreat of the mocha stone moth as shown in Plate XXXIX, Fig. 1. With the first signs of spring the larvae become active and begin feeding upon the developing buds of

the host. By the end of June they have reached maturity and after seeking a sheltered nook, such as a crevice in the tree, in cracks of fences, etc., transform to the pupal stage. The length of this period is about 3 weeks and at the end of this time the moths emerge. They are attracted in tremendous numbers to strong lights and in the infested territory the light and line poles in the immediate vicinity of arc lights sometimes are almost plastered with the bodies of the moths. The eggs are deposited in the position and manner described. The eggs hatch in late summer and the young larvae, feeding in colonies on the tender terminal leaves, web them together to make the winter retreat. Thus it will be seen that there is but one brood per year.

Both the male and the female moths fly, and because of this fact the distribution of the species is much more rapid than that of the gipsy moth. Masters of sailing vessels have reported encountering swarms of the moths from 75 to 100 miles out at sea and authentic records exist of the capture of moths 42 nautical miles from the nearest infested territory.

Nature of injury.—The newly-hatched caterpillars feed at first upon the epidermis of the leaf, but as they grow older the entire leaf structure excepting the veins is consumed. In the spring of the year when the partly-grown caterpillars leave their retreats and begin feeding, the expanding buds are devoured, and if the tree is well supplied with caterpillars it may be kept in a defoliated condition during the entire summer. Successive defoliations by the caterpillars or the prevention of the development of the foliage is quite capable of causing the death of the host as has actually happened in thousands of cases in New England.

Another type of injury is the rash or eruption of human beings caused by the spined hairs of the caterpillars and to a less extent caused by the brown hairs from the abdomen of the moth. The trouble is commonly referred to as "brown-tail rash," and with the more susceptible persons is so annoying as to preclude their dwelling within the bounds of infested territory. Not only is the irritation of an external nature but internal as well, since the breathing of the floating and broken hairs irritates the tissues of the lungs and serious results occasionally follow.

Food plants.—The brown-tail moth is a much less omnivorous feeder than the gipsy moth, though most of our fruit and deciduous forest trees are attacked and occasionally herbage is eaten. Conifers are not attacked and seldom is hickory, ash, chestnut or birch injured.

Distribution.—Like the gipsy moth the brown-tail is widely distributed in Europe. In the United States it occurs in all the New England states, the infested area being considerably greater than that occupied by the gipsy moth. Northward, it has spread to Nova Scotia and New Brunswick.

Natural enemies.—As with the gipsy moth, the brown-tail is well supplied with natural enemies in its native habitat where its ravages are greatly minimized by them. With this species also, the Federal Bureau of Entomology is making every effort to introduce and establish these natural controls. While discouragements have been encountered, the work is meeting with a satisfactory measure of success.

For a list of the natural enemies of the brown-tail moth and a report of the work of introduction into the United States, the reader is referred to the publication of Howard and Fiske (38) cited in connection with the parasites of the gipsy moth.

Control.—When practicable of application, such as in orchards and on small trees, the collection and destruction of the conspicuous hibernating nests during the winter months is recommended. On large trees and over extensive areas, spraying with poisons is more practicable. The work should be done in August when the caterpillars are small in order to yield success. At this time arsenate of lead used at the rate of 8 pounds of paste to 100 gallons of water is sufficiently strong.

Spraying in the spring when the larvae begin feeding is not so successful, since at that time the insects are larger and more difficult to poison; and at the same time, since they feed upon the expanding buds, very little surface is present for the spread of the poison. If, however, the fall spraying or collecting the winter nests has not been done, the spring application is advised but the poison solution at that time should be stronger. No less than 10 to 12 pounds of paste arsenate of lead should be used to 100 gallons of water.

SCALE AND OTHER SUCKING INSECTS

The group of insects to be discussed in the following pages is, as a class, inconspicuous in appearance but among them are some of the worst known pests of shade and forest trees. Because of their unobtrusiveness it frequently follows that plants become infested and seriously injured before the depredator is known to be present.

As a whole the insects of this group and particularly the scale insects are more destructive under urban than rural conditions. Several reasons may be given for this fact: In the first place, most scales seem to thrive best upon hosts with weakened constitutions, and the adverse conditions attending plant growth in cities and villages tend to promote this; second, abundant opportunity exists for introduction and distribution through the constant transference of planting stock; third and final, a wide range of hosts is available so that the various insects, and particularly those having cosmopolitan feeding habits, are not hampered by lack of suitable food.

THE SAN JOSE SCALE

(*Aspidiotus perniciosus* Comst.)

The San Jose scale is the most destructive scale insect of fruit trees in the State and causes severe injury to some ornamentals. It cannot, however, be classed as a pest of general importance on forest and shade trees. Some few species, nevertheless, are attacked with considerable severity, such as osage orange, sometimes used in plantings for post timber. For this reason, and also because some ornamentals are injured, a discussion in a publication of this kind appears necessary.

Description.—The trunk, limbs and branches of a tree, badly infested with San Jose scale have a characteristic gray, ashy appearance; and, if a knife blade is drawn over an area plastered with the insects, a yellow, oily juice is crushed out.

Individually, the full-grown female scales are flat, circular, about one-twelfth of an inch in diameter, and with a slightly raised central area, or nipple, which is dark or yellow. (See Plate XLVII, Fig. 1.) The body of the female is without eyes, legs or antennae, is slightly oval, light yellow in color and is somewhat smaller than the scale covering.

The male scale is smaller that that of the female, is about twice as long as broad and is black in color. The male insect is a fragile, pink, winged creature which flies readily during calm weather. The young insects are minute, bright yellow, louse-like creatures which for the most part are born alive, though occasionally the mother

expels them covered with a thin, sack-like membrane which is soon broken open, allowing the insect to emerge.

Life history and habits.—The winter is passed in a partly-grown condition beneath the shelter of the round scale cover, which at that time is coal black. With the advent of spring, growth continues and the males mature and emerge from beneath their scale coverings. They seek the females, mate and perish. By late June the females have matured and the crawling young insects begin to appear. Upon finding a suitable place, they settle down upon the host, insert their hairlike, needle-sharp beaks into its tissue and begin to imbibe the sap. White waxy hairs now spring up from pores in the insect's back, which mat it over, forming a pure white covering, and after several days this turns black. In about 2 weeks the insect molts, losing its legs and antennae and the females their eyes. With continued growth and successive molts the scale is enlarged. The males mature in from 3 to 5 weeks and mate with the females, but the latter do not reach maturity until they are from 4 to 7 weeks old.

Each female may produce several hundred young but perhaps does not average more than 150 to 200. This period of production extends over several weeks. Thus the first-born themselves may be producing young before the last of their sisters are born, and this accounts for the fact that the insect in all stages of development may be seen during the summer.

There are several broods per year.

Nature of work.—The hundreds of thousands of sap-sucking scale insects of a badly-infested plant rob it of its juices and literally dry it up, ultimately resulting in death. With most infested plants it will be noted upon cutting into the bark or when examining fruit or foliage that the lighter-colored parts usually are stained red. This and other indications have led to the belief that in addition to the mechanical injury resulting from the loss of sap, the insect may exert a toxic effect upon the host. The final type of injury, one which has little bearing upon the subject in its present consideration, is the spotting or discoloration of fruit and foliage due to the attacks of this species.

Food plants.—Dr. W. E. Britton (39), in his second annual report, published a list composed of 138 species of plants upon which the San Jose scale is known to subsist. This list was later republished by Doctor Felt (28). By referring to either of these publications the reader will see that this species may be considered a general feeder, although on the other hand some of our best trees are not subject to attack by it.

Distribution.—The San Jose scale occurs in every county in Ohio and in every important fruit-growing district in the United States. Its native home is China, from which it was introduced into the United States on nursery stock, first becoming established in San Jose, Cal. The principal means of spread from locality to locality is by the transfer of infested nusery stock. Locally it is distributed by the young larvae drifting in the wind and by their clinging to moving birds, insects, floating spider webs, etc.

Natural enemies.—During the last two or three seasons natural control agencies have been exceedingly active in some sections of Ohio, and as a result of their work the damage by scale has been greatly decreased. Indeed, in some sections the scale has almost disappeared. It is to be hoped that the law of nature's balance is asserting itself and that we are entering an era in which the San Jose scale will not be the menace it once was.

It is not known definitely just what control agencies are responsible for the present changed condition, but indications point to unusual activities by internal Hymenopterous parasites. The known list of these tiny wasp-like creatures is larger than one at first would suppose. The following have been reported: *Aphelinus fuscipennis, A. mytilaspidis, Aspidiotiphagus citrinus, Anaphes gracilis, Physcus varicornis, Prospaltella aurantii, P. perniciosi, Ablerus clisiocampae* and *Rhopoidens citrinus*. Several lady beetles are known to attack the San Jose scale. The two species most useful in Ohio are the tiny, coal black species *Microweisea misella*, and the twice-stabbed lady bird, *Chilocorus bivulnerus*, which is a larger insect, coal black in color with a red spot on each wing cover.

The writer observed at Ironton, Ohio, an instance where currants had been rid of an attack of San Jose scale by the work of a red fungus, *Sphoerostilbe cocophila*.

Control.—Under urban conditions perhaps the most generally satisfactory control measure consists in spraying the infested trees or shrubs with soluble or miscible oil, since this material does not stain the paint of buildings as do the sulphur sprays. The oil is diluted at the rate of 1 part to 15 parts of water and is applied in the spring before the buds break. Where danger of staining does not exist, any of the various sulphur sprays except the self-boiled may be used with good success.

It should be remembered, as with all spraying for scale insects, that thoroughness of application is absolutely essential to success.

PUTNAM SCALE
(*Aspidiotus ancylus* Putn.)

Description.—Putnam scale so closely resembles the San Jose that quite frequently it is mistaken for the other species. However, it is a much less injurious insect since it multiplies much less rapidly and also since it has a much more limited list of hosts.

The female scales are of about the same size and shape as those of the San Jose, that is, one-twelfth of an inch in diameter, but the general color is a little darker and the nipple-like structure is a little to one side instead of being in the center and is brick red in color. (See Plate XLVII, Fig. 2.)

The male scales are smaller, elongate and with the nipple at one side.

Life history and habits.—The winter is passed in the partly-grown condition, but the insects are a little farther developed than are the over-wintering San Jose scales. The fragile, winged males appear in April, and the egg-laying females deposit their quota of from 30 to 40 eggs each in the early summer. The eggs are deposited under the shelter of the scale, and the young, hatching before midsummer, settle upon the bark and form their scale coverings. There is but one generation each year.

Nature of work.—In the role of a shade tree pest this insect is occasionally destructive, infesting trunk, limbs and branches of the host. Under Ohio conditions trees rarely are killed outright by Putnam scale, but it is no uncommon sight to find them injured to the point of unsightliness.

Food plants.—Soft maple and linden are more susceptible than any other hosts, but in addition to these this scale attacks ash, elm, hackberry, black locust and a number of other trees and shrubs including several of the fruits, such as apple, currant, pear, etc.

Distribution.—This species occurs throughout the State and over the greater part of the United States.

Natural enemies.—Hymenopterous parasites are important natural controls as will be noted by the large number of exit holes in the scales of nearly every infestation.

Control.—The control measures recommended for the San Jose scale are equally effective against this species.

THE ENGLISH WALNUT SCALE
(*Aspidiotus juglans-regiae* Comst.)

Description.—Three characteristics render the English walnut scale fairly easy to differentiate from its near relatives, the San Jose, Putnam, etc., even with no more equipment than the ordinary

hand lens. In the first place it is larger than most others, the mature female scale measuring one-eighth of an inch in diameter. Moreover, the young scales have a characteristic habit of clustering about the mother in very regular formation as indicated by the accompanying illustration, Plate XLVII, Fig. 3. Very frequently one finds the mother scale surrounded by a perfect circle of young. Finally, when the scale is removed and the body of the mature female is exposed, there will be seen a deep notch on each side of the anterior, rounded portion, thus abruptly setting it apart from others of this group.

The general body color of the mature female scale is gray and the reddish-orange exuvium is slightly to one side. The male scale is smaller and elongated.

Life history and habits.—The winter is passed in the adult stage, the female laying her eggs in early spring. Hatching occurs soon and by June this brood has matured and the eggs for another brood have been deposited. There are two and perhaps more generations annually.

Nature of work.—Twigs and the smoother bark on limbs and trunk are affected by this species, sometimes with such severity as to encrust the bark. The English walnut scale is much worse in cities than in the country, sometimes actually killing trees, but more frequently merely giving them a sickly, unhealthy appearance.

Food plants.—Linden, horse-chestnut and buckeye are the most severely infested of the common Ohio trees, but the list of hosts embraces ash, maple, apple, box-elder, elm, cottonwood, currant, cherry, locust, peach, pear, plum, English walnut, prune, sweet gum and apricot.

Distribution.—This insect occurs in most parts of Ohio and is widely distributed over the United States.

Natural enemies.—The following Hymenopterous parasites are reported by Essig (41) as having been reared from this scale: *Aphelinus diaspidis* How., *Encyrtus ensifer, Prospaltella aurantii* How. and *Signiphora occidentalis* How.

Control.—The standard sulphur sprays and miscible oils applied in the usual dormant strengths have proved satisfactory control measures for this species in experimental work in Ohio.

THE OBSCURE SCALE
(*Chrysomphalus obscurus* Comst.)

Description.—As the name signifies, the obscure scale is rather difficult to detect, particularly when it occurs on oaks and other

trees with very dark-colored bark. On trees with lighter bark, this characteristic it not so pronounced, the scales standing out with considerable prominence.

The female scale is about one-tenth of an inch in diameter, almost circular in form and dark gray in color. The exuvium is jet black, particularly when rubbed. The scale covering is harder and more rigid than the average. When removed from the bark it leaves a decided white spot.

The male scale is smaller, oval and convex anteriorly. It is of the same color of the female. (See Plate XLVII, Fig. 4.)

Nature of work.—The bark of twigs, limbs and branches is infested by this scale, and the injury frequently is sufficient to cause the death of the host. In other cases only branches and limbs succumb. A tendency toward clustering is noted with this species, particularly when it is infesting beech. An unusual type of injury to beech was noted in 1914 in Burnett Woods and other parks in Cincinnati. There the infestation assumed the shape of bands an inch or less in width around the smaller limbs, and beyond the collar of scale the limbs were dead. Limbs from 1½ to 2 inches in diameter seemed more susceptible to injury of this sort than those of any other size.

Food plants.—Oaks are more generally considered the favorite host of this species, but in the region of Cincinnati beech seems preferred. At any rate it suffers to a greater extent than any other plant. The hosts reported are as follows: Hickory, grapevine, beech, willow oak (*Quercus phellos*), *Quercus coccinae, Q. acuminata, Q. macrocarpa*, pecan (*Hicoria ovata*) and maple. The writer has also taken this species upon English walnut.

Distribution.—The obscure scale is more abundant in southern than in northern Ohio. In some sections of the southwestern part of the State it is very abundant, invading both urban and rural districts. The species is very abundant in the southern states and extends westward to include those of the west-central group.

Control.—In the writer's experience 33° lime-sulphur used at the rate of 1 to 7 and applied in the spring has failed to control this species. Miscible oil used at the rate of 1 part to 15 of water and applied at the same time gave favorable results. Only a few young scales developed during the following season on trees so treated while new scale was abundant on nearby unsprayed checks.

THE OYSTER SHELL BARK LOUSE

(*Lepidosaphes ulmi* Linn.)

The oyster shell bark louse is almost as widely distributed as the San Jose scale but while the San Jose scale is largely a fruit tree

pest, the present one is much more prevalent and destructive as a shade tree and forest insect, on account of the high susceptibility of a number of native trees and shrubs to its attacks. Indeed, it may be classed as the most destructive shade tree and forest scale insect in the State.

Description.—As the name indicates, this scale insect resembles a miniature oyster shell. It is pointed at one end, and gradually increases in width, the opposite end being broad and rounded. The scale varies of course according to the condition and species of the host, but generally the female is from one-tenth to one-eighth of an inch in length and the male about one-sixteenth of an inch in length. The mature female scale insect is sacklike and devoid of appendages, while the mature male is winged. (See Plate XLVIII, Fig. 1, for an idea of the general appearance of the scale.)

The eggs are oval, pearly-white in color and are found beneath the scale covering in masses of a hundred or less.

The newly-hatched young scale insects are minute, yellowish and crawl about freely.

Life history and habits.—The insect passes the winter in the egg stage, well protected by the securely cemented down scale of the mother. By mid-May or early June, the eggs hatch and the young, after a short period of wandering, settle on the bark and commence sucking the sap. The scale is then formed. Growth continues; the sexes develop and mature. Later the eggs are deposited which constitute the over-wintering form.

Nature of work.—The robbing of the host of its sap supply by the myriads of minute pumping insects so devitalizes it that where the infestation is severe the plant may be killed outright or at least parts of it perish.

It is no uncommon sight to find susceptible hosts both under city and country conditions dead as the result of the work of this species. In some instances which have come to the writer's attention entire woodlots of ash have been cut prematurely on account of the threatened total destruction by it. (See Plate VI.)

Under city conditions the injury is sometimes severe and extended, the more susceptible hosts being killed outright by it.

Food plants.—Quaintance and Sasscer (40) record a list of ninety-nine plants upon which this scale is known to occur. In Ohio the more common hosts, named somewhat in the order of their susceptibility are as follows: Carolina and lombardy poplar, lilac, horse chestnut, buckeye, ash, cottonwood, willows, apple, red-twig dogwood, etc.

Distribution.—This insect occurs throughout Ohio, although it is more prevalent in the vicinity of the larger cities than in the rural districts. Outside Ohio it occurs in most sections of the United States, the area of greatest destructiveness being the northern part, particularly the northwestern.

Natural enemies.—The history of the activities of the oyster shell bark louse in Ohio indicates that the insect is periodically destructive, and that following each outbreak will ensue a period of comparative inactivity. Thus it is clearly indicated that natural control agencies play an important role in the insect's life economy. An examination of the dead scales following the passage of the crest of such an outbreak reveals the fact that many are pierced with tiny holes indicating the escape of internal parasites. Of the known internal parasites, the following may be named: *Aphelinus diaspidis* How., *A. fuscipennis* How., *A. mytilaspidis* Le B., *A. abnormis* How., *Aspidiotiphagus cirtinus* Craw., *Anaphes gracilis* How. and *Cheiloneurus diaspidinarum* How.

A mite, *Hemisarcoptes coccisugus,* is known in France as a predator upon the eggs of this scale.

Ladybird beetles destroy considerable numbers of these insects, and the following birds have been reported of value in this respect: brown creeper, black-capped chickadee, titmice and the white-breasted nuthatch.

Control.—Spraying with the sulphur sprays or with miscible oil during the dormant period is the most satisfactory control method to be used against this species under Ohio conditions. The sulphur sprays should be used at the usual strengths, that is, 1 part of the standard liquid lime-sulphur to 7 parts of water and the proprietary powders at the strengths recommended by the manufacturers. The miscible oils should be used at the rate of 1 part to 12 to 15 parts of water

While these materials are the most effective known at this time, yet as much as 3 years may be required to subdue the pest if the attack is severe and the scales are piled one upon another, since the oyster shell bark louse is one of the more resistant scales.

Occasionally and particularly in years past it has been recommended to make a summer application of kerosene emulsion at the time the young appear, but this is not advisable due to the fact that the brood does not appear simultaneously and because of the difficulty in covering every twig and branch of the host when the foliage is out.

The application of control measures is rarely if ever feasible under woodlot conditions, for the expense of the operation far exceeds the results obtained since woodlot trees are usually high and the cost of treatment correspondingly great.

THE SCURFY BARK LOUSE
(*Chionaspis furfura* Fitch)

The scurfy bark louse and the oyster shell bark louse are quite commonly associated, but of the two the latter is the more serious pest, first, because it attacks a wider range of host plants, second, because it is more destructive in its action, and, third, because it is more difficult to control.

Description.—The male and female scales of the scurfy bark louse vary greatly in appearance. The female scale is pear-shaped in outline, is almost flat and is about one-tenth of an inch in length. Scales found in woods away from dust and smoke are almost pure white with a yellow tip, but when found in cities and in situations where foreign particles collect upon the surface, they vary in color from light to very dark gray. The surface is dull, not glossy.

The male scales are much smaller with almost parallel sides and the surface is broken by three ridges extending lengthwise. They too are white under sanitary conditions and darker in the presence of smoke, dust, etc., but are not so seriously discolored under similar conditions as are the female scales. The mature female insect is without appendages, sacklike and is not motile. The male scale is winged and very fragile. (See Plate XLVIII, Fig. 3.)

The eggs are minute, reddish-purple and are found beneath the protection of the mother scale. Quaintance and Sasscer (40) found that the average of eggs of 20 individuals was 57 eggs each.

The young are minute, reddish and are motile for a short time after hatching.

Life history and habits.—The winter is passed in the egg stage beneath the shelter of the female scale. The eggs hatch during late May or early June and the young move about actively for a day or two, whereupon they settle on the host, begin feeding and form the scale covering. By late summer the sexes have matured; the female deposits her quota of eggs and dies, and her body shrivels up into the dark, misshapen object one finds beneath the narrow point of the scale.

There is but one full brood in Ohio, but a partial second brood may occur.

Nature of work.—To young trees or trees of low viltality, the injury by this species is severe, sometimes causing the death of the

host. Usually, however, infestations are sparse. The insect attacks the trunk, branches and occasionally the fruit of the host, and like the San Jose scale has a tendency to cause red spots to appear around the point of attack.

Food plants.—Quaintance and Sasscer (40) list forty plants as hosts of this species. A decided preference is shown for apple, hawthorn, currant, mountain ash, chokecherry, etc.

Distribution.—This is a native insect and is found generally distributed throughout the State and the United States. It occurs in both rural and urban districts.

Natural enemies.—Three predaceous enemies have been recorded for this species: *Tyroglyphus malus* Shimer, *Hyperaspis* sp., and the twice-stabbed ladybird *Chilocorus bivulnerus* Muls. The following parasitic Hymenoptera have been recorded: *Ablerus clisiocampae* (Ashm.), *Physcus varicornis* How. and *Prospaltella* sp.

Control.—The best control method consists in spraying with any of the sulphur sprays or miscible oils in the strength and at the time recommended for the San Jose scale, viz., while the trees are dormant. In addition this species may be controlled by spraying, in late May or early June when the brood of young appears, with kerosene emulsion or whale-oil soap. However, the dormant period is a much more satisfactory time in which to do the work, because it is possible to do more thorough spraying when the tree is free from foliage.

THE WILLOW SCURFY SCALE

(*Chionaspis salicis-nigrae* Walsh)

Description.—The willow scurfy scale is the largest of the scurfy scales, measuring from one-eighth to one-sixth of an inch in length. The shape is slightly pyriform, and the scale is slightly the widest in the middle. It differs still further from the other scurfy scales in that it has a slightly glossy appearance as if coated with a transparent varnish. (See Plate XLVIII, Fig. 2.) The male scales are much smaller, slender, with almost parallel sides and with the body slightly ridged.

The eggs are oval and purplish red and the newly-hatched young are of the same color.

Life history and habits. The winter is passed in the egg stage. Hatching occurs in late May or early June. There are probably two broods per season.

Nature of work.—The twigs, branches and trunk of the host are attacked, occasionally with such severity as to cause the death of parts or the whole of it. As a rule, however, it is not so severe

in its action and a plant may possibly be infested for a number of years without serious harm resulting.

Food plants.—This species shows a decided preference for willow, but has been reported upon the following hosts: *Cornus pubescens, C. asperifolia, C. stolonifera,* deer bush, big-leaf maple, poplar, *Amelancher canadensis* and tulip tree.

Distribution.—This species occurs throughout the State and is found throughout the northern section of the United States.

Control.—In the experience of the writer, the standard, liquid lime-sulphur wash used at the rate of 1 part to 7 of water, and the home-boiled sulphur sprays have proved adequate for the control of this species.

THE DOGWOOD SCURFY SCALE

(*Chionaspis corni* Cooley)

Description.—The appearance of the dogwood scurfy scale is typical of the scurfy group, the female being white and less than one-eighth of an inch in length. (See Plate XLIX, Fig. 2.) The male scale is much smaller, slender and with three distinct ridges extending lengthwise of the body. The eggs are small, oval and purple in color. The winter is passed in this stage.

Nature of work.—For the most part, this species apparently prefers to attack the lower parts of the plant. Occasionally this area is encrusted and parts of the plant die. While not a very serious pest, it sometimes is sufficiently plentiful on some varieties of dogwood in parks to require treatment.

Food plants.—Two species of dogwood have been reported as hosts: *Cornus alternifolia* and *C. paniculata.*

Distribution.—This scale is found in both woodlands and in city plantings. It is encountered more frequently in the northern than in any other section of the State. In addition to this state it has been reported from Massachusetts and Indiana.

Natural enemies.—Hymenopterous parasites are active agents against this species.

Control.—Standard lime-sulphur applied before the buds break in the spring is effective as a control spray.

THE ELM SCURFY SCALE

(*Chionaspis americana* Johns.)

Description.—The female of the elm scurfy scale differs somewhat from the typical scales of the scurfy group; having something of the general appearance of the oyster shell scale. While originally white, the scale is usually so thoroughly covered with minute bits of refuse that it is very dark gray in color. It is a little less than

one-eighth of an inch long, plainly convex and when removed from the bark a conspicuous white scar remains. The male scale is white, slender and with three distinct ridges extending lengthwise of the body. (See Plate XLIX, Fig. 3.) The eggs are ellipsoidal and purplish.

Life history and habits.—The winter is passed in the egg stage, the young appear in late spring and two generations are produced annually.

Nature of work.—Twigs, branches and large limbs of the host are attacked. Young trees are killed outright sometimes, but on older trees the injury assumes the form of a lowering of the general vitality of the host and a killing of smaller branches, thus causing it to assume a ragged, frowsy appearance.

Food plants.—American elm (*Ulmus americana*), Camperdown elm (*Ulmus scabra pendula*) and *Ulmus montana* var. *camperdown pendula* are attacked by the elm scurfy scale.

Distribution.—This species occurs throughout Ohio, and in all situations where its hosts are found.

Natural enemies.—The larva and adult of the ladybird, *Chilocorus bivulnerus*, have been observed feeding on this species and two parasites, *Perissopterus pulchellus* and *Physcus varicornis* have been bred from it.

Control.—The sulphur sprays or the miscible oils applied in the normal dormant strengths before the buds break in the spring are specific control agencies for this species.

THE PINE LEAF SCALE
(*Chionaspis pinifoliae* Fitch)

Description.—Tiny, elongate, white objects with a yellow pellicle attached to one end found infesting pines and some other conifers usually are the scales of the pine scurfy scale. The females average about one-eighth of an inch long and the males are smaller. The females vary in width, depending upon the host. For instance, when the species is found on the slender needles of the white pine the female scales are very slender, but when infesting other pines with broader needles or other species of conifers, usually the scales are broader. (See Plate XLIX, Fig. 1.)

The purplish eggs, 20 to 30 in number, are found beneath the parent mother scale.

Life history and habits.—The winter is passed in the egg stage, the young hatching in May. Egg-hatching extends over a considerable period. By late summer, the first individuals of the first brood have matured and eggs for the second brood are deposited. There are two broods per year in Ohio.

Nature of work.—The needles only of the host are attacked and where the infestation is only moderate no very serious results attend the presence of the pest. When the attack is severe, the needles become yellow and parts or the entire tree may die. It is not very common, however, for the attack to end fatally.

Food plants.—The following conifers have been recorded as hosts of the pine scurfy scale: *Pinus strobus, P. resinosa, P. excelsa, P. mitis, P. cembra, P. pyrenaica, P. laricis, P. sylvestris, P. austriaca, P. pumilo, Pseudotsuga taxifolia, Picea excelsa, Picea nigra and Picea alba.*

Distribution.—This species abounds throughout the State, particularly in and near towns and cities. Its range extends to embrace practically all of the states of the northern section of the Union but it is most prevalent east of the Mississippi River.

Natural enemies.—Two parasites, *Perissopterus pulchellus* and *Aphelinus mytilaspidis* have been reared from this species. The following list of predators has been reported as preying upon it: *Chilocorus bivulnerus, Scymnus* sp., *Cocinella picta, Chrysopa* sp., and *Cybocephalus nigritulus.*

Control.—Our present knowledge of control methods for this species is in a rather imperfect condition. Doubtless the normal winter strength of lime-sulphur wash or miscible oil would prove effective against the scale when applied during early spring, as has been done in the writer's experience, but neither are recommended at this time because of probable injury to the host. While the few white pines which the writer sprayed with these materials were not injured by the treatment, the test was not sufficiently comprehensive to warrant general conclusions. It is possible that of the two classes of materials, the sulphur sprays would be less likely to cause injury since it is generally considered that conifers are intolerant to oily mixtures. On one occasion, in 1903, the writer sprayed a large number of pines on the Ohio Experiment Station campus, using weak kerosene emulsion in May when the young of the spring brood were hatching; in late summer an application of whale-oil soap was made to the same trees when the young of the summer brood appeared. The combined treatment effectually reduced the infestation and it is likely that summer spraying is the safest control measure to be used against this species. No definite dates can be given when the spraying should be done, since the time of the appearance of the young varies with the character of the season. The infested pines should be watched and when the brood of crawling young appears, the spraying should be done. The first brood

may be expected in May or early June and the second one of the season in late summer.

THE HONEY LOCUST SCALE
(*Chionaspis gleditsiae* Sanders)

Description.—The scale of the female of the honey locust scale is thin, fragile, frequently covered with a sooty secretion and is but little more than one-sixteenth of an inch in length. In heavy infestations the bark of the host presents a dark-gray appearance as if weathered newspapers were pasted snugly over it. The male scale is smaller, white, and distinctly ridged. (See Plate L, Fig. 1.) The eggs are purplish-red, and it is in this stage that the winter is passed.

Nature of work.—The principal injury is to the bark of the host, and while the writer has never seen a case where an attack could be said to be fatal, yet the sapping by the insects decreases vitality and retards growth. Not infrequently control measures are advisable in the case of shade and park trees.

Food plant.—The honey locust (*Gleditsiae triacanthos*) is the only host recorded.

Distribution.—This insect has been taken in extreme southwestern and extreme northeastern Ohio, as well as in many intermedial points both in woodland and artificial plantings, hence it seems safe to assert it is likely to be found wherever its host grows. Outside of Ohio the species has been reported from Indiana (42) and Mississippi (43). It is to be expected therefore that the species has a rather wide distribution.

Natural enemies.—Hymenopterous parasitism is common, but the writer has not bred out the adult form.

Control.—One experiment only has been conducted by the writer by way of testing artificial control measures for this species and that involved the use of the soluble sulphur compound. This material was used at the rate of 13 pounds to 50 gallons of water and was applied to badly-infested honey locust in Eden Park, Cincinnati, Ohio, March 29, 1915. The control was absolute. Since it has been our experience with other species that the other sulphur sprays will control the forms controlled by the soluble sulphur compound, it seems reasonable to expect the same perfomance in regard to this species.

THE EUONYMUS SCALE
(*Chionaspis euonymi* Comst.)

Description.—Although the euonymus scale is one of the true scurfy scales, the female scale resembles that of the oyster shell

group in general appearance more than it does the typical scurfy scale. It is rigid in texture, highly convex and covered with a dark deposit which gives it a very somber, inconspicuous appearance; thus contrasting sharply with the white or gray color of the majority of the scurfy scales. The female scale is a little over one-sixteenth of an inch in length and strongly pyriform. The male scale is white, and much smaller than the female. (See Plate LI, Fig. 1.)

Life history and habits.—The winter is passed in the egg stage securely protected by the rigid scale of the mother insect. From these over-wintering eggs young emerge in late May or in June and two broods at least develop during the summer.

Nature of work.—Trunk, branches and leaves of the host are attacked, frequently with fatal results to parts of or even the entire host. Plate LI, Fig. 2, conveys a very good impression of the destructive work of this species.

Food plants.—The euonymus scurfy scale has been reported as attacking the following food plants: *Euonymus europaeus, E. latifolia, E. japonica, E. radicans* and *E. atropureus,* as well as some of the horticultural varieties of these species. It has also been reported from bitter-sweet (*Celastrus scandens*), *Althea* sp. and orange.

Distribution.—The writer has but three records of this insect in Ohio; Cincinnati, Wooster and Cleveland. At Wooster a climbing, evergreen euonymus (*E. radicans* var., *broad leaf*) was killed by it and a clump of *E. europaens* very severely injured in Cleveland. The records of its distribution outside the state are as follows: Massachusetts, New York, New Jersey, Pennsylvania, Virginia, North Carolina, South Carolina, Georgia and California. Further, it is reported from Cuba, France, Italy and Japan.

Natural enemies.—One small hymenopterous parasite, *Aphelimus fuscipennis,* has been reared from this scale.

Control.—The standard liquid lime-sulphur wash, used at normal strength as a winter spray has failed in the experience of the writer to control this species. Miscible oil, however, applied in early April at the strength of 1 part of oil to 15 parts of water gave almost perfect results. Summer spraying with kerosene emulsion or whale-oil soap may be resorted to at the time the young appear, but as in the treatment of other scale insects this rarely is as satisfactory as the winter applications.

THE ROSE SCALE
(*Aulacaspis rosae* Bouche)

Description.—The female scales are almost circular, a little less than one-eighth of an inch in diameter and usually snow-white in color. The male scale is long and narrow with three ridges running lengthwise of the body. The eggs are purple. Usually the scales are found in masses at the base of the host instead of being distributed evenly over the surface, those of the two sexes being mingled. (See Plate L, Fig. 2.)

Life history and habits.—The winter is passed in the egg stage and the young appear over a rather prolonged period, beginning in late May or in June.

Nature of work.—While rarely fatal, this insect nevertheless does considerable harm by way of weakening the host. Artificial control measures, therefore, are necessary, particularly in parks and other ornamental plantings in cities.

Food plants.—Roses, blackberry, dewberry, raspberry, mango, myrtle, pear, sago palm and Tree of Heaven serve as hosts for this species.

Distribution.—This insect is distributed probably over most of the United States and is known to occur in many widely separated parts of the world.

Natural enemies.—The rose scale is known to be attacked by at least two hymenopterous parasites, *Aphelinus diaspidis* and *Arrhenophogus chionaspidis*.

Control.—The sulphur sprays as well as the miscible oils applied at dormant strength during the early spring before foliage starts are known to be effective control measures for this species. As has been shown previously, the infestation often is low down and may be protected quite thoroughly by an accumulation of fallen leaves, hence one should take the precaution to remove these before spraying starts.

THE COTTONY MAPLE SCALE
(*Pulvinaria vitis* Linn.)

Description.—The cottony maple scale is among the most conspicuous of the group and on occasion may be classed among the most destructive. The scale proper is unobtrusive, but the large ovisac, snowy-white when first formed and later becoming soiled and gray, makes the insect very noticeable.

The body of the female scale insect varies greatly with the season. In the spring it is insignificant in size and is difficult to see because of its close color resemblance to the bark of the host.

With the coming of the foliage it grows larger and thicker, and a large conspicuous cottony mass is secreted among the waxy strands of which are found the eggs. The formation of the egg-mass causes the body of the female to become elevated so that it ultimately sets at an angle. See Plate LII, Figs. 1 and 2, for illustrations of the general appearance of the insect at this time.

The male scale is much smaller, flat, and the male scale insect is a delicate two-winged creature.

The eggs are oval, light colored and slightly reddish-yellow. The females deposit about 3,000 eggs each.

Life history and habits.—The cottony maple scale passes the winter as a small, flat, brown object secured to the twigs of the host. Growth starts in early April; the cottony mass is secreted and eggs deposited in late May or early June. The eggs hatch in late June or early July and the young establish themselves upon the leaves, usually on the underside and along the midrib and veins. The males become mature in August or September, fertilize the females and perish. Before the foliage drops, the females migrate to the twigs and establish themselves for the winter.

Nature of work.—During the majority of seasons, the damage created by this pest is not severe, but during occasional years the insects appear in enormous quantities and great numbers of trees may be killed outright. It is the opinion of Dr. S. A. Forbes, of Illinois, that these destructive outbreaks may be expected to occur about every 8 or 10 years in communities in which the insect becomes established.

Food plants.—This pest is most destructive to soft maple and basswood or linden. However, it can subsist upon a considerable number of plants and may be considered as a destructive enemy to some. The reported list is as follows: Norway maple, sugar maple, *Acer dasycarpum*, box elder (*Negnudo negundo*), osage orange, red mulberry, *Aralia japonica*, apple, pear, alder, willow, hawthorn, poplar, currant, lilac, grapevine, oak, hackberry, sycamore, rose, currant, Euonymus, locust, sumac, beech, poison ivy, elm, poplar, plum, peach, gooseberry and Virginia creeper.

Distribution.—This insect abounds in the United States and Canada, and is well known in Europe. It is stated by Sanders (44) to be most destructive north of the 40th parallel, and that it is distinctly an Upper Austral zone species but occasionally reaches the Transition zone.

Natural enemies.—In July, 1916, large numbers of a lady-beetle, *Hyperaspis signata binotata* Say appeared at Wooster and did perceptible good, both as larvae and adults in destroying the cottony

maple scale. Another lady-beetle, *Chilocorus bivulnerus* Muls. is reported as an enemy. As a usual thing, however, minute parasitic wasps may be considered the most useful of our natural enemies against this insect, the following having been reported: *Cocophagus lecanii* Fitch, *C. flavoscutellum* Ashm., *Atropates collinsi* How., *Aphycus pulvinariae* How., *Comys fusca* How. and *Eunotus lividus* Ashm. In addition to the foregoing list may be named as enemies of this scale, a predaceous caterpillar, *Laetilia coccidivora* Comst., a dipterous parasite, *Leucopis nigricornis* Egger and a bird, the common English sparrow.

Control.—Some value may be attached to the use of kerosene and other oily emulsions applied in the summer when the young are appearing, but at best this treatment is satisfactory in part only, due to the mechanical difficulty attached to spraying thoroughly when the host is in foliage. In the writer's experience far more satisfactory results have been obtained by spraying with miscible oil, 1 part to 15 parts of water, in the spring before the buds break. This treatment destroys the over-wintering partially-mature females attached to the twigs and smaller limbs. A word of caution, however, should be expressed, that quantities of the oily spray should not be permitted to soak into the soil at the base of the tree since maples are sensitive to the action of oils.

COTTONY MAPLE-LEAF SCALE
(*Pulvinaria accricola* Walsh and Riley)

Description.—This scale insect closely resembles the foregoing species in general appearance. However, aside from the minute microscopial differences, it may be differentiated easily because the body of *acericola* is dotted with blotches of white cottony wax while the body of *vitis* is bare. Moreover, *aericola* usually occurs during the adult stage on the leaves of the host, while *vitis* is found upon the twigs and branches. (See Plate LII, Fig. 3.)

Life history and habits.—Both males and females of the cottony maple-leaf scale pass the winter in a partially matured condition upon the twigs of the host. By late April or early May of the following spring, the males mature and after fertilizing the females, the latter migrate to the leaves where they reach maturity, secrete their white cottony ovisac and deposit their eggs. The following June the larvae begin to hatch. They feed for a time upon the leaves and later migrate to twigs and branches for the winter. There is but one brood per season.

Nature of work.—The injury caused by the cottony maple-leaf scale is not so severe as that caused by the maple cottony scale.

First, this species is not as prevalent and, second, the leaves only of the host are greatly affected while its near relative attacks the more important twigs. Occasionally, however, it demands treatment.

Food plants.—But two hosts, the soft maple (*Acer saccharinum*) and the sugar maple (*A. saccharum*) are reported for this species.

Distribution.—Apparently this scale is a native American species. It has been reported from Massachusetts, New York, New Jersey, District of Columbia, Tennessee, Ohio, Indiana, and some of the western states.

Natural enemies.—The lady-beetle, *Hyperaspis signata* Oliv., a small fly, *Leucopis nigricornis* Egger, and the following list of hymenopterous parasites have been reported as destroying this pest: *Aphycus hederaceus* Westw., *Aphycus flavus* How., *Coccophagus fraternis* How., *Pachyneuron altiscuta* How., and *Chiloneurus albicornis* How.

Control.—The same control is recommended for this species as was given for the cottony maple scale.

THE MAPLE PHENACOCCUS
(*Phenacoccus acericola* King)

Description.—Quite frequently the maple phenacoccus is mistaken for the cottony maple-leaf scale, just described, since both appear upon the underside of maple leaves, but the two may be differentiated with ease, since the present species appears as an irregular cottony mass, about one-fourth of an inch in diameter, the cottony secretion completely covering the insect's body and egg mass, while the cottony maple-leaf scale appears as a distinct fluted ovisac with the brown body of the insect attached at one end. Compare Figures 3 and 5 of Plate LII. At certain seasons of the year the young, crawling females and the white cocoons of the males may be found in great quantity upon the trunk of badly infested trees. (See Plate LII, Fig. 4.)

Life history and habits.—The partially-grown crawling scale insects pass the winter within the shelter of crevices in the tree trunk, emerging the following spring and migrating to the underside of the leaves. They mature and deposit upon an average of about 500 eggs in the white, cottony egg-covering. These eggs hatch and the cycle is repeated two or three times during the summer.

Nature of work. In the writer's experience this insect has never been observed inflicting great harm in Ohio, though a few instances have come to his attention where individual trees were

rather severely attacked. More extensive outbreaks have been recorded from other states. In Massachusetts and some of the other New England States it is considered a serious pest of street trees.

Food plants.—While maple without doubt is the chief food plant, the insect has been reported upon hornbeam, lime and horse chestnut.

Distribution.—The northeastern quarter of the United States constitutes the area over which the maple Phenacoccus is most frequently found.

Natural enemies.—The following natural enemies have been recorded for this scale: Lady-beetles, *Hyperaspis signata* Oliv., *Chilocorus bivulnerus* Muls. and *Anatis ocellata* Oliv.; Syrphid fly, *Baccha fascipennis* Wied.; Chalcid, *Rhopus coccois* Smith and *Chrysopa* sp.

Control.—Miscible oil at the rate of 1 gallon to 15 of water applied in the spring before the buds break is the most generally approved control measure. Whale-oil soap is reported as yielding favorable results, as is also kerosene emulsion. Whatever the material used, it should be applied with particular thoroughness to the trunk and rougher branches of the host to have it penetrate to the secreted, hibernating insects, and the work should be done before the foliage starts in the spring.

THE MAPLE TERRAPIN SCALE

(*Lecanium nigrofasciatum* Perg.)

Description.—The maple terrapin scale, or black-banded scale as it is sometimes called, is sharply hemispherical in form when full grown and varies in length from one-eighth to one-sixth of an inch. It is slightly narrower than long. The general color is reddish-brown with varying degrees of black banding or mottling. Sometimes an individual will be entirely red or black. The usual mottled appearance and characteristic form so closely remind one of the land terrapins in miniature that the insect is known by some as the terrapin scale. Distinct ridges radiate to the outer border from a smooth, brown, central area, increasing in distinctness as the border is approached. One of the most distinctive characteristics, however, is a peculiar, nauseating odor released when the fresh specimens are crushed. The males are fragile, winged creatures which are rarely observed unless bred out in confinement. The eggs are pale yellow and are deposited under the shell-like scale. (See Plate L, Fig. 3.)

Life history and habits.—The females only of the terrapin scale survive the winter months and these are in a partially matured condition. By early June of the year following, maturity is reached; eggs are deposited and the young appear in late June or early July, the process extending over a considerable period of time. The males prevail during late August, function and die. Sometime later the females migrate to the underside of the smaller twigs and settle themselves for the winter. There is but one generation annually.

Nature of work.—Sapping the twigs in spring and fall and the leaves during a portion of the summer, the maple terrapin scale is capable of inflicting great injury to the host when the infestation is severe. Moreover, the excretions from the insects, collecting upon foliage and twigs, promote the development of a sooty fungus which mars the beauty of the host and must, to a considerable extent, interfere with the process of transpiration.

Food plants.—While called the maple terrapin scale, this insect does not confine its attacks to maple trees, but is almost equally injurious under Ohio conditions to sycamore. Occasionally in Ohio, and more frequently in the eastern states it is an important enemy of peach. In addition to these hosts the following have been reported as infested: plum, apple, pear quince, *Crataegus* sp., Carolina poplar, olive, blue-berry (*Vaccinium* sp.) Brumelia and spice bush (*Benzoin benzoin.*)

Distribution.—The area of greatest prevalence of this insect is the Eastern United States but according to Sanders (45) it occurs in every state east of the Mississippi and in Missouri, Arkansas, Louisiana, Texas and Minnesota. It is also reported from the Province of Ontario, Canada.

Natural enemies.—The following hymenopterous parasites have been recorded for this scale (46): *Coccophagus lecanii* Fitch, *C. cinguliventris* Gir., *C. longifasciatus* How., *Aphycus stomachosus* Gir., *A. cognatus* How., *Anagyrus nublipennis* Gir. and *Eucyrtus* sp. The ladybird, *Chilocorus bivulnerus,* is reported as is also a fungus, probably *Cordyceps clavulata.*

Control.—Summer operations against this insect with a view of destroying the newly-hatched larvae are not practicable because the larvae appear over a rather extended period, thus necessitating several sprayings, and because the presence of the foliage precludes thoroughness of application. The most satisfactory control, therefore, lies in early spring applications directed against the hibernating females. Lime-sulphur and the other sulphur sprays are in-

effective but the miscible oils applied at the rate of 1 part to 15 parts of water are entirely satisfactory. The work should be done just before the buds break in the spring.

THE TULIP TREE LECANIUM

(*Toumeyella liriodendri* Gmel.)

Description.—The tulip tree lecanium is one of the very largest of the group of fleshy scales. When permitted to develop without crowding, the adult female is hemispherical in shape, about one-third of an inch in diameter and of a rich dark brown color. However, the scales usually are found in clustered, crowded masses, whereupon they become very much distorted and misshapen. (See Plate LIII, Fig. 2.)

Life history and habits.—The small, flat, inconspicuous immature scales (See Plate LIII, Fig. 1) pass the winter securely attached to the twigs of the host. Development is rapid after tree growth starts in the spring and the young, as recorded by Professor Cook in Michigan, appear in late August. There is but one brood annually.

Nature of work.—Many instances have come to the writer's attention where entire trees were in a dying condition because of the work of this insect and it is much more common to find dead branches, particularly the lower ones dead from this cause. An incidental form of damage is the choking of the stomata because of the profuse discharge of honey-dew and the attending growth of mold. Further this honey-dew falls upon sidewalks and the moldy growth renders the walks particular untidy. Finally the honey-dew attracts myriads of insects which contribute still further to the discomfort of pedestrians and nearby residents.

Food plants.—The tulip or yellow poplar (*Liriodendron tulipfera*) is the principal host of this species. The scale has been recorded, however, upon magnolia.

Distribution.—The tulip tree lecanium is distributed throughout Ohio, both as a city and forest pest. In some of the remote woodlands of southern Ohio the writer has found it in severe infestations and has encountered it occasionally infesting forest plantations. The tulip scale has been recorded also from Massachusetts, Connecticut, New York, New Jersey, Tennessee, Western States and Europe.

Natural enemies.—But one parasite, *Coccophagus flavoscutellum*, Ashm., has been recorded for this species. The lady-beetle, *Hyperespis signata binotala*, was observed at Mineral, Ohio, July 12, 1916, associated with this scale.

Control.—On March 26, 1915, the writer sprayed tulip trees in Marietta, Ohio, which were very badly infested with this scale. The day was warm and sunny, temperature 42° to 46° F. Scalecide, diluted at the rate of 1 part to 15 parts of water was used and the application was made with a power sprayer.

On July 22, 1915, the sprayed trees were examined and were found to be in perfect condition, clothed with an abundance of clean, bright-green foliage and no live scale present. Nearby, unsprayed trees presented the usual disgusting appearance of trees badly infested with this scale. The leaves were sooty, as was also the sidewalk, and visiting insects were present in countless numbers. Indeed it was one of the most striking demonstrations of spraying results the writer ever saw.

The foregoing experience has been borne out in other instances in the State, hence miscible oil, used at the rate of 1 part to 15 parts of water, applied in the spring before foliage starts is a safe and reliable control for the tulip tree scale.

THE MAGNOLIA SCALE
(*Neolecanium cornuparvum* Thrs.)

Description.—In many respects the magnolia scale closely resembles the foregoing species. It is larger, however, the mature females measuring almost one-half of an inch across, but flatter. In late July or early August just before the young begin to appear it is abundantly covered with a white, mealy wax, giving the host the appearance of having bits of dough stuck to the branches. It is the largest and most conspicuous of our scale insects. (See Plate LIII, Fig. 3.)

Life history and habits.—As is characteristic of many scales of this group, the winter is passed by the immature scale insects of this species upon the twigs of the host. By late July or early August of the following summer, growth is complete and the young begin to appear. There is but one brood per season.

Nature of work.—Death of the host may result from the unrestricted action of this scale (See Plate LII, Fig. 4), and in any case where the insects are at all abundant the attractiveness of the host is marred by the sooty mold which thrives upon the abundant discharge of honey-dew of the scales. As with the preceding species a second incidental result is the scourge of insect visitors attracted by the sweet honey-dew.

Food plants.—As the name of the scale would suggest, the various species of magnolia are the principal hosts of this scale. It has been reported also as affecting Daphne and Virginia creeper.

Distribution.—The magnolia scale has been observed by the writer in various sections of Ohio. It has been reported by others from New York, Pennsylvania, Maryland, Virginia and Louisiana.

Natural enemies.—The larvae and adults of the lady-beetle, *Hyperaspis signata binotata,* were observed September 20 and October 3, 1914, feeding voraciously upon the young of this scale. Entire areas of the scale infestation had been destroyed by the beetle and its young, so it would seem that it may be considered a valuable natural control.

Control.—Carefully made applications of the lime-sulphur wash, failed utterly in the writer's experience to control this species. However, scalecide, applied at the rate of 1 part to 15 parts of water in the early spring, yielded perfect results and may be considered a safe and certain measure to employ. If but a few magnolia shrubs are affected, hand picking the large, white, conspicuous scales in July before the young appear is at once effective, practicable and inexpensive.

THE EUROPEAN ELM SCALE
(*Gossyparia ulmi* Linnaeus)

Description.—The European elm scale is so unusual in appearance that a glance at the illustration of the adult female (Plate LIV, Fig. 1) almost renders a description unnecessary. The body of the adult female is reddish brown in color, plump and from one-fourth to three-eighths of an inch long. It rests on a mass of white, waxy material, the edges of which extend up on the sides of the body, somewhat like a fringe, that reminds one in a measure of a bird sitting on her nest. The insects are found in greatest abundance in the crevices of the bark of the host and upon the underside of the limbs. The eggs are oblong in shape and pale yellow in color. The newly-hatched young are pale-yellow, six-legged creatures, later becoming gray and woolly. The males are fragile, reddish, two-winged insects, which issue abdomen first, or in other words, back out of snow-white, elongate cocoons.

Life history and habits.—The European elm bark louse passes the winter as a partially developed larva. (See Plate LIV, Fig. 2.) The following spring the sexes mature, mating occurs and the females begin ovipositing. The young appear in late June. The young first establish themselves upon the foliage, favoring above all other positions the axils on the underside of the leaf formed by the junction of the midrib and veins. Here they remain for a time, later migrating to the trunk and limbs for hibernation. There is but one brood annually.

Nature of work.—The European elm bark louse colonizes the lower limbs of the host first, but may infest the entire top. At Marietta, Ohio, the writer has observed a number of trees killed outright by it and many others in a depleted condition. (See Plate LIV, Fig. 3.) Not only does this insect cause positive injury to the host but its copious discharge of honey-dew promotes the profuse growth of an unsightly, sooty mold over the foliage of the host (See Plate LV, Fig. 1), sidewalks and other objects, and at the same time attracts myriads of flies and other insects. Altogether, therefore, its presence is the cause of much unpleasantness as well as injury.

Food plants.—The European elm scale confines its attacks to the various species of elm and of these, the red elm (*Ulmus fulva*) is the most susceptible. Other species observed by the writer are the American elm (*U. americana*) ; and the cork elm. In addition to these, the following species have been reported as hosts: English elm, slippery elm, and Wych or Scotch elm.

Distribution.—In Ohio, the center of greatest injury is in the city of Marietta, where the magnificent street and park elms in some parts of the city are rather severely attacked. Elms on one or two streets in Columbus are known to be infested and a single report has been received from Cleveland. We have no further records of its presence in Ohio. However, the insect has an extended range of distribution, having been reported from Vermont, Massachusetts, District of Columbia, Michigan, Nevada, California, New York, Maine, Connecticut, Maryland, Washington, New Jersey, Indiana, Canada and Europe.

Natural enemy.—The twice-stabbed ladybird (*Chilocorus bivulnerus*) has been recorded as preying upon this scale.

Control.—Miscible oil used at the rate of 1 gallon to 15 gallons of water and applied in the spring before the foliage starts, in the writer's experience has proven an efficient control measure. In cooperation with the city of Marietta, Ohio, a considerable number of large elms were sprayed March 27 to 30, 1916, with this material in the strength given and the results were all that could be desired. Still further work has confirmed these findings.

Summer spraying with kerosene emulsion at the time the young are appearing is sometimes advised, but this plan is not satisfactory since several applications are required to kill the continuous procession of young insects. It is also advised as a control measure that the trees be drenched with the hose in order to dislodge and destroy the larvae as they appear, but this treatment likewise has

its limitations because of the necessary repetition. In some instances where unusual facilities exist for drenching, this control method has considerable merit.

THE BURR OAK KERMES
(*Kermes pubescens* Bogue)

Description.—This insect might appropriately be called the oak leaf-crinkling kermes because of the peculiar distorting effect it has upon the leaves of the host, which will be described later. (See Plate LV, Fig. 2.) This is one of the fleshy scale insects, and is not covered with a protecting shield or cover.

The adult female is almost globular, although slightly longer than broad and is about one-eighth of of an inch long. (See Plate LV, Fig. 2.) They are found in greatest abundance upon the smaller twigs, leaf petioles and midribs. Clothing the body of the female is a downy pubescence, and it is due to this material that the species was given its specific name *pubescens*. When this pubescence is rubbed off, the derm or surface appears shiny and is beautifully marked with dark and light brown mottlings, the darker portions of which assume more or less distinct lines, one median line extending lengthwise and this crossed at right angles by two or three others of a similar nature. When the females are removed from the host, a distinct white patch remains.

The young are red, mite-like, six-legged, crawling creatures.

The males emerge from tiny white cocoons which are located mainly upon the underside of the twigs and branches. They are delicate reddish-hued creatures having two long filaments extending backwards.

Life history and habits.—The partly-grown females pass the winter in the shelter of crevices in the bark of the host. From these retreats they emerge in the following spring at the time foliage development starts and establish themselves upon the tender twig tips, leaf petioles, leaf midribs and veins. The majority are found upon the leaves. Leaf distortion commences almost simultaneously with the establishment of the scale insects and as the insects develop in size the supporting leaf becomes more and more distorted.

By mid-May during the time the burr oaks are in blossom, the males leave their cocoons. The process of emergence is curious. First, the white filaments appear at the tip of the cocoon; next, the tip of the abdomen and lastly the head. The insect becomes quite active, orients itself, and seeks seclusion in the crevices of the bark of the host. When disturbed it takes flight. By August 1 in the vicinity of Cincinnati, the young have been produced, but the bodies

of the dead females still adhere to the host, some persisting until the following year.

Nature of work.—The writer has never observed a tree killed by the burr oak kermes, but it is no uncommon sight to find dead twigs. Unquestionably the presence of the insect in numbers is perceptibly devitalizing to the host and the unhealthy, distorted, unnatural appearance of the foliage detracts greatly from its natural beauty. In Ohio where the pest abounds it may be considered an important if not the most important enemy of the burr oak.

Food plants.—The burr oak (*Quercus macrocarpa*) is the more common host of this species, but other oaks as follows, have been recorded: Chinquipin oak (*Q. prinoides*); white oak (*Q. alba*); and red oak (*Q. rubra*).

Distribution.—In Ohio this insect is known to occur in Columbus and Cincinnati, having rather wide distribution in the parks of the latter place. It is reported also from Indiana, Massachusetts, Kansas and Kentucky.

Natural enemy.—A red mite was observed by the writer to feed with avidity upon the emerging males August 4, 1913.

Control.—On March 27, 1915, and April 4, 1916, the writer sprayed burr oaks in the Cincinnati parks, badly infested with the burr oak kermes. Scalecide 1 part to 15 parts of water was used. In the first instance the work was done with the ordinary type mist sprayer, but in the second the solid stream type, equipped with a three-sixteenths of an inch nozzle was used. The trees sprayed in 1916 were from 65 to 70 feet high.

In both the foregoing instances the control was absolute. The trees sprayed in 1916 were not sprayed in 1917. In May, 1918, they were again examined and were found not only to be practically free from the scale, but also had in some measure recovered from the effects of the previous attack while the nearby trees, reserved as checks were very badly infested. It may be stated, therefore, that miscible oil, applied in the spring before the foliage starts, is a satisfactory control agency for this species.

THE PIT-MAKING OAK SCALE

(*Asterolecanium variolosum* Ratz.)

Description.—The pit-making oak scale is one of the most distinctive of the scales occurring in Ohio. It is also known by some as the golden oak scale; both names being well suited to the insect. A glance at Plate LVI, Fig. 1, conveys an idea of the pit-making propensities of the species, the twigs and branches of the host appearing strongly poc-marked when infested. The illustration does not bring out the beautiful greenish-golden coloration of the

living scale insects. The scale of this species is slightly convex and of a circular outline, measuring about one-sixteenth of an inch in diameter.

Life history and habits.—On May 11, 1915, the writer observed the young just beginning to appear at Cincinnati, Ohio. Beneath the upper scale surface of the female was found a mixture of eggs, quiescent young and active young. Apparently, the young remain inactive a little while after hatching and later make their way from beneath the rear tip of the waxy scale mass. The number of eggs, quiescent young and active young appeared to be about 50 for each female insect. On July 19, 1907, the newly-emerged young were observed in quantity at Cleveland, Ohio, so there seems to be considerable latitude in Ohio as to the time of the appearance of the young. It is supposed that there is but one brood of young per season in Ohio, but this fact is not definitely known.

Upon emerging the young establish themselves and begin work. The lower branches of the host as a rule are more severely infested than the upper ones.

Nature of work.—The pit-making oak scale is one of the more destructive scales of oak when it once becomes established. Large as well as small trees are killed outright. Badly-infested trees present a ragged appearance and the dead brown leaves hanging to the dead branches are particularly noticeable and unattractive. (See Plate LVI, Fig. 2.)

Food plants.—The writer has taken the pit-making oak scale on English oak (*Quercus robur*), white oak (*Q. alba*) and a pyramidal oak, the species of which he does not know. Other workers have reported it upon white swamp oak (*Q. platinoides*), a golden oak (*Q. glandulifera*) and *Q. sessiflora*.

Distribution.—The pit-making oak scale has been reported from the following localities in Ohio: Mentor, Glendale, Edgewater Park, (Cleveland), and numerous places in the parks and on the streets of Cincinnati. Outside of Ohio it is known to occur in Europe, Canada, Massachusetts, Connecticut, New York, District of Columbia, Pennsylvania, Michigan, Maryland, New Jersey, Virginia, North Carolina and California. Special attention should be drawn to the prevalence of this scale in the Cincinnati district. There it is well distributed through the parks of the city and occurs on street trees as well, sometimes killing large oaks 35 to 40 feet in height.

Natural enemies.—A small hymenopteron, *Habrolepis dalmanni* Westw., has been reported as parasitic on this species in this country; and two birds, the blue tit and the long-tailed tit, have been reported from England as feeding upon it.

Control.—In the experience of the writer, the sulphur sprays in dormant strength application have failed completely to control this species. Good success has been had, however, from the use of miscible oils used at the rate of 1 gallon to 12½ and also 15 gallons of water. These materials even when applied during adverse weather conditions, viz.: when the thermometer stood at 31° F. were, so far as could be ascertained, 100 percent efficient. Because of these favorable results miscible oil is recommended as the best control measure. The application should be made in the spring before the buds break.

Kerosene emulsion and whale-oil soap sometimes are recommended as summer applications when the young appear, but because of the uncertainty of the time of this period and because of the difficulty involved in spraying when the plants are in foliage, the dormant miscible oil application is much to be preferred.

THE COMMON RED SPIDER OR SPIDER MITE
(*Tetranychus* sp.)

Description.—The effects of the work of this mite are more noticeable than the creature causing the trouble. Indeed it is only the most critical observer who ever sees the mite proper, since it is much smaller than a pin head. The unaided eye may detect tiny moving objects but a lens is required to differentiate details. When viewed with a lens, the spider mites are found to be eight-legged creatures, actively running about over a network of webs which they spin upon the surface of the host. They may be red, green or brown in color and usually have two well-defined spots on the back.

The eggs are minute and almost spherical in shape. When first deposited they have a faint pearly color, but later become reddish. (See Plate LVII.)

Life history and habits.—Under outdoor conditions the winter is passed in Ohio in the egg stage, the young appearing after the foliage is well developed in the spring. There are several generations annually, and each female is capable of producing a large number of eggs. In greenhouses and conservatories development is continuous the year around. Badly-infested plants invariably are found to be covered with a network of very fine webs which the mites use for concealment and also to enable them to run about quickly from one place to another.

Nature of work.—The mites feed by piercing the leaf tissues from the underside and sucking out the juices. During the process, some of the chlorophyll is removed and the leaf may take on a mottled appearance. If the mites are sufficiently numerous the

entire leaf structure dries up and dies. Entire defoliation may result. Indeed, it is no infrequent thing in Cincinnati for basswood to lose two crops of foliage in a year because of the work of these mites. The rusty, unhealthy appearance of tree foliage, particularly during late summer, usually is due to the work of these mites. During dry seasons, the injury as a rule is much more severe than at other times.

Food plants.—The spider mites are almost omnivorous, and to give the complete list of food plants would mean naming almost every common plant in the State. However, some are much more severely injured than others, and of the trees, the linden or basswood may be given as the most susceptible to attack. However, the oaks and some other species are attacked with almost equal severity.

Distribution.—The spider mites abound throughout the State, but may be said to be more injurious in the southwestern than in other sections. In the southern and western states this pest is unusually prevalent, though it undoubtedly occurs in every state of the Union. It is also a well-known pest in Europe and in other parts of the world.

Natural enemies.—Ewing (47) gives a list of fourteen natural predators, including other mites, lady beetles, Syrphid larvae and lace-wings.

Control.—No very satisfactory control methods are known for this species when attacking shade trees. In the spring of 1916 the writer tested the value of miscible oil, 1 part to 15 parts of water, applied during the dormant season with the view of destroying the over-wintering eggs. The application was made to a European linden located in Eden Park, Cincinnati, Ohio, which had lost two sets of foliage the season previous because of the mite injury. The tree was well supplied with over-wintering eggs at the time of application. The summer following the treatment, the tree retained its foliage during the entire season although the mite was prevalent in 1916. Some injury was noted on the sprayed tree which might be attributed to but partial control or to reinfestation from neighboring untreated trees.

With valuable trees, the spraying with oil would be practicable, but under average park conditions it is questionable whether the expense involved would be justifiable.

Frequently drenching the infested trees with water is practiced by some with fair success. Where such facilities are available this method undoubtedly has more practical merit than any other. The object in the drenching is to dislodge and destroy the mites.

PLANT LICE
(*Aphididae*)

While plant lice constitute one of the most important families of destructive insects, from the standpoint of destructive shade and forest tree pests, they rank quite low. With one or two exceptions, therefore, they will be treated as a group.

Description.—Plant lice are soft-bodied, winged or wingless insects which for the most part are gregarious. The legs are long and slender, as are usually the antennae, and the mouthparts are fitted for piercing the food plant and sucking its juices. With most species there are several generations annually, many of the females having the power to bring forth living young without the intervention of males.

Natural enemies.—Plant lice because of their lack of natural protecting armor and because of their sluggishness, fall an easy prey to many parasites and depredators. Lady beetles, both in the adult and larval stages; the larvae of Syrphus flies; the larvae of lace wings (*Chrysopidae*); Hymenopterous parasites and fungous diseases all contribute in holding the plant lice hordes in check.

Control.—Frequently the dormant sprays applied for scale control are important checks against plant lice. During the summer months, when plants become infested, a number of materials may be employed, but one of the most universally satisfactory is nicotine sulphate used at the rate of about 1 part to 500 or more parts of water, with enough soap added to form a suds. This soapy, tobacco spray should be applied in such a manner as to bathe the lice since it is effective only when it comes in contact with the insect's body.

THE PINE BARK APHID
(*Chermes pinicorticis* Fitch)

Description.—The pine bark aphid is a true plant louse, but the insect itself is rarely seen, since usually it is hidden beneath a mass of white, cottony secretion. These cottony masses occur in greatest abundance on the trunk and larger branches of the host and when numerous are very conspicuous. (See Plate LVIII, Fig. 1.) The adult insects are dusky to reddish in color, some being winged and some wingless. The eggs are oval, dusky-yellow and are secreted in downy wax at the base of the needles.

Life history and habits.—The first young appear in late April or in early May and there are several generations during the season.

The winter probably is passed by the female lice within the protection of the cottony secretion, though it is possible that during some seasons hibernation occurs in the egg stage. At any rate if the females over-winter, oviposition occurs very early in the spring since the writer has observed eggs as early as April 28.

Nature of work.—Pines attacked by this aphis become sickly, the needles turn yellow, limbs may die and occasionally the entire tree succumbs. As a rule, however, only smaller trees die. The white patches on trunk and limbs disfigure the tree and detract seriously from its appearance.

Food plant.—The writer has never observed this insect upon any other plant than the white pine.

Distribution.—The pine bark aphid is distributed throughout Ohio. It has been reported also from Connecticut, Illinois, New York, Iowa, Maryland, Maine, New Jersey, Minnesota and Canada. It is likely that the insect is much more widely distributed than the foregoing list would indicate.

Natural enemies.—Four lady beetles, *Anatis* 15-*punctata* Oliv., *Adalia bipunctata* Linn., *Chilocorus bivulnerus* Muls. and *Megilla maculata* De G., have been recorded as preying upon this scale. In addition to these, the larvae of Syrphid flies and ant lions have also been noted.

Control.—Spraying in the spring when the first brood of young is appearing is the most satisfactory control measure. For this purpose, kerosene emulsion diluted at the rate of 1 part of standard stock emulsion to 9 parts of water has been recommended. Nicotine sulphate at the rate of 1 part to 500 parts of water with enough soap added to make a suds would be a safer remedy to apply and probably would yield satisfactory results.

THE COCKSCOMB ELM GALL

(*Colophc ulmicola* Fitch)

Description.—The cockscomb elm gall is illustrated in Plate LVIII, Fig. 2. As the name indicates the gall has much the shape and appearance of a cock's comb. During a part of the summer the gall has a decidedly red cast which contributes further toward its resemblance to the comb of a cock.

These galls are the direct result of the work of a glossy, greenish-brown plant louse. The gall proper appears upon the upper side of the leaf, and when the affected leaf is turned over, a slit will be noted on the underside which marks the position of the

base of the gall. When the slit is spread, the lice will be noted within the gall.

Life history and habits.—The cockscomb gall plant louse over-winters as a shiny brownish egg within the protection of the rough bark of the host. Coincident with the development of the foliage the following spring, the eggs hatch and the young migrate to the leaves where the gall is formed. During June, when these galls are opened, the mother louse within will be found surrounded by numerous young.

Later the mouth of the gall opens, allowing the escape of the young, and at the same time large quantities of honey-dew are released.

Nature of work.—The distortion of the foliage caused by the presence of the galls becomes a serious handicap to the tree in instances of severe attacks. The dehydration of the leaf tissues by the feeding lice and the annoyance to residents caused by the discharge of quantities of honey-dew and the attending fungous growth contribute still further to make the pest unwelcome.

Distribution.—This insect is found in all parts of Ohio, and widely distributed in other sections of the United States.

Control.—Rarely is it advisable to attempt control measures, since the presence of the insect rarely is discovered until the galls are formed, and after that time the insects within are secure from the action of sprays. With small, valuable trees, hand picking the gall-bearing leaves might be practiced and the following spring the trees might be sprayed with dormant strength lime-sulphur or miscible oil in order to destroy any over-wintering eggs and thus contribute toward the prevention of a recurrence of the outbreak.

THE CATALPA MIDGE

(*Itonida catalpae* Comstock)

Description.—The catalpa midge in the adult stage is a fragile two-winged fly. It measures about one-sixteenth of an inch in length, the legs are long and the body is light yellow in color while the wings are dusky. The eggs are minute, elongate, whitish and when deposited on the foliage are found in masses of 80 or more.

The larva when mature is nearly one-eighth of an inch in length and varies in color from pale-whitish to orange. It possesses the ability to spring into the air to a height of several inches, the feat being performed by bringing both ends of the body together in bow fashion and suddenly straightening out. For illustrations of the foregoing stages see Plate LIX, Figs. 1, 2 and 3.

Life history and habits.—The winter, in all likelihood, is passed as pupae within the soil, the adults emerging in late May or early June. Eggs are deposited upon the unfolding leaves and the larvae soon make their appearance. They are found in great quantity upon the underside of the leaves, snug against the midrib and veins, being aided materially in maintaining their position by reason of the short down which clothes this portion of the leaf. As early as June 5 larvae in abundance have been observed at Wooster. Within a short time, some of the larvae change to pupae within their retreats on the leaf, others transform within the shelter of the malformed growing tip of the host, but probably the greater number drop to the ground and perform their transformations beneath the surface of the soil.

The life cycle is completed during midsummer in from 3 to 4 weeks, according to Prof. H. A. Gossard (48). There are several generations annually, but the two broods of larvae appearing in early June and early July, respectively, do the greatest injury.

Nature of work.—The stunted growing tips of catalpa; the distorted leaves; the brown eye-like spots or larger browned, deadened areas on the leaves and the distorted, misshapen pods all are the effects of the activities of this insect.

The injury to the foliage may take the form of circular feeding punctures about one-fourth of an inch in diameter (See Plate LIX, Fig. 4), or in the event of a destructive attack the entire leaf may wilt (See Plate LX, Fig. 1), later becoming brown and crumpled. (See Plate LX, Fig. 2.) Frequently the trees may shed a considerable part of their foliage as a result of early summer outbreaks.

When the larvae gain access to the pods considerable distortion results and if abundant, the greater part of the seed may be destroyed. (See Plate LIX, Fig. 5.)

The most serious aspect of the injury by the catalpa midge consists in the stunting and dwarfing of the trees as a result of the constant killing back of the terminal bud. (See Plate LX, Fig. 3.) When grown for posts or poles it is vitally important to rapid and satisfactory development that the terminal shoots and particularly the central one remain healthy and vigorous. Repeated injury to the terminal shoot causes excessive branching and the outcome is a dwarfed bushy growth instead of the straight, upright tree. (See Plate LX, Fig. 4.)

Food plant.—Catalpa is the only known host.

Distribution.—The catalpa midge has been reported from the District of Columbia, Indiana and Ohio. Doubtless, however, it is

much more widely distributed than the foregoing records would indicate.

Natural enemies.—We have repeatedly bred a chalcid, *Zatropis catalpae,* from material collected at Wooster, and a lace-wing larva *Chrysopa* sp., has been observed feeding upon the larvae.

Control.—Unfortunately for the catalpa industry, no satisfactory control measure is known for this species. It has been observed, however, that cultivated groves are less seriously attacked than uncultivated ones, hence it is advisable that cultivation be practiced until the trees are well started.

THE SYCAMORE LACE BUG
(*Corythuca ciliata* Say)

Description.—The sycamore lace bug is not a well-known shade tree pest in Ohio, regardless of the fact that it is well distributed and does considerable harm each season. In fact, it has up until recently received but scant attention from entomologists. Its life history as well as other items pertaining to its economy have been worked out and published during the past year. See Bulletin 116, Oklahoma Agricultural Experiment Station, by Otis Waid.

The sycamore lace bug belongs to the family of insects called the *Tingitidae,* members of which take their food in the form of sap. The adults are a little over one-sixteenth of an inch in length and are about half as wide as long. They are much flattened, and the wings as well as the thorax are beautifully sculptured to resemble an intricate, lacy network. It is because of this fact that the insect merits its common name. (See Plate LXI, Fig. 1.)

The younger or nymphal stages closely resemble the adult in general conformation, but lack the characteristic lacy appearance. They are generously ornamented with spines on the sides and back. (See Plate LXI, Fig.3.)

Life history and habits.—The winter is passed by the adult insects under the shelter of the bark scales and on the trunk of the host and in other similarly protected positions. With the appearance of the sycamore foliage in the spring, the adults emerge and oviposit on the underside of the leaves. Within a few days, the exact time depending upon the temperature at that season, the eggs hatch and the series of seasonal generations is started. Waid found under greenhouse conditions which approximated late spring weather, that a little over a month was required for the insect to pass from the egg and through the five nymphal instars to the adult stage. It is possible therefore for several generations to develop during a single summer, particularly since the period of the life

cycle may be somewhat shortened during the favorable conditions of summer. Under Ohio conditions the adults begin to seek their winter quarters by mid-October.

Nature of work.—The harm inflicted by the sycamore lace bug consists in the sapping of the foliage by the feeding insects clustered on the underside of the leaves. Both nymphs and adults are active in this respect. When the attack is severe a whitening and deadening of the foliage results. (See Plate LXI, Fig. 4.)

Food plants.—The sycamore lace bug, in so far as is known, attacks sycamores only of which there are two species in Ohio: the common sycamore or buttonwood (*Platinus occidentalis*) and the European form (*P. acerifolia*).

Distribution.—This insect is found throughout the greater part of the United States east of the Rocky Mountains.

Natural enemies.—The natural enemies reported by Waid are as follows: a *Chrysopid*, assassin bugs (*Reduviidae*), spiders, a red mite, and a predaceous heteropteran (*Triphleps insidiosus*, Say).

Control.—After a series of experiments which involved the use of kerosene and crude-oil emulsions, nicotine sulphate, concentrated lime-sulphur and fish-oil soap solutions, Waid decided that of the materials tested, fish-oil soap used at the rate of 1 pound to 6 gallons of water was most satisfactory. Since the material kills by contact only and since the insects as previously stated inhabit the underside of the leaves, particular care should be taken to direct the spray upwards and to do the most thorough work possible. At least 150 pounds pressure and preferably nozzles of the large disk type or the spray gun should be used.

BORING INSECTS

Among the borers are found some of the most destructive shade tree and forest insect pests. Moreover, in the main there is little to be done by way of applying artificial control measures.

THE LOCUST BORER

(*Cyllene robiniae* Forst.)

Description.—The adult is a slender, long-horned beetle, varying in length from one-half to three-fourths of an inch. The general body color is velvety-black, beautifully marked with bright, yellow lines extending crosswise of it. The legs and antennae are rich, dull yellow. (See Plate LXII, Fig. 2.)

The eggs are elongate, snow-white and large enough to be seen plainly with the unaided eye. They are found in crevices of the bark. (See Plate LXII, Fig. 1.) The larva is about three-fourths of an inch in length and decidedly club shaped. (See Plate LXII, Fig. 3.) The pupa is almost as long as the larva is, yellow in color, and is found in the burrows made by the larva.

Life history and habits.—The beetles appear in September when they may be seen in abundance feeding upon the flowers of goldenrod (See Plate LXIII, Fig. 1) or nervously running up and down the trunks of locust trees searching for a place to lay their eggs. It is while feeding on goldenrod that the average observer most frequently sees the beetle.

Any roughened area on the trunk of the host is acceptable to the beetle for oviposition, the scars resulting from previous operations being favored situations. The eggs may be deposited in clusters or may be laid singly. Frequently a part of the egg remains exposed.

The eggs soon hatch and the tiny larvae bore their way into the bark, feeding upon the soft inner portions. In this situation the small larvae pass the winter. In the spring they resume feeding and boldly eat their way into the hard heartwood of the host. A knot or enlargement forms about the entrance hole of the feeding larva and in time the trunk of the host becomes much deformed. See Plate LXIII, Fig. 2, for a typical section of an injured tree.

Larval growth is completed by midsummer, the insect pupates within the larval burrow and the adults emerge in September.

Nature of work.—As the name indicates, this is a true boring insect. It attacks those parts of the host which are covered with roughened bark; thus on young trees the work is confined largely to the trunk, while on large ones the limbs also are affected. Heart

and sapwood both are attacked. Not only is the timber from infested trees seriously mutilated and weakened, but wood-invading fungi and bacteria are invited by the incisions in the bark of the growing trees and the burrows left by the insect in posts and poles, promote decay.

Some trees are killed outright, while others, weakened by the insect, may be broken over or limbs may be blown off in storms.

When all phases of its work are considered, this is the most severe insect depredator of the black or yellow locust in Ohio.

Food plant.—The yellow or black locust (*Robinia Pseudacacia*) is the recorded host for the larva and the adult feeds upon the flowers of goldenrod.

Distribution.—The locust borer is found throughout the greater portion of the United States east of Colorado and has been reported from Canada.

Natural enemy.—The wheel bug (*Prionidus cristatus*) has been recorded as destroying the adult beetles of the locust borer.

Control.—Successful and practicable measures for the control of this insect have never been found. Prized trees may be protected for a time, until they become too large, by opening up the burrows of the boring larvae, introducing therein a small lump of potassium ferrocyanide, and closing the opening with putty or grafting wax. Repellent washes applied to the trunk during the egg-laying season have proven both expensive and only moderately successful. The destruction of goldenrod in the vicinity of locust groves is thought by some to possess merit, since the process removes the source of attraction for the adult beetles. For the protection of large plantings or the wild growth of woodlands, an effective control measure is yet to be found.

THE LOCUST TWIG BORER
(*Ecdytolopha insiticiana* Zell.)

Description.—In its injurious stage this insect is a whitish or pale yellowish larva about one-half of an inch long. The adult is a moth with a wing expanse of about three-fourths of an inch. The fore wings are dark ashy-brown with a dull pinkish-white patch on the outer part. Within this patch are several small black spots. The hind wings are lighter.

Nature of work.—The locust twig borer is found within swellings borne by the smaller twigs of black or yellow locust. These swellings measure from 1 to 3 inches in length, a characteristic specimen being illustrated in Plate LXIV, Fig. 1. White sawdust-like castings are discharged from a hole in the larger part of the

swelling. The larvae become mature by mid-autumn, drop to the ground and pupate among the leaves. Occasionally a large percentage of the twigs of a grove is affected by this insect and under such conditions tree growth is checked perceptibly.

Food plant.—The black or yellow locust (*Robinia Pseudacacia*) is the only host recorded.

Distribution.—This insect has been reported from the District of Columbia, Massachusetts, Indiana, West Virginia, New York and New Jersey. It is found in all parts of Ohio.

Control.—Cutting and destroying the infested twigs during the summer before the larvae escape is of some value, but is practicable only upon a very limited scale.

THE POPLAR BORER
(*Saperda calcarata* Say)

Description.—In the adult stage the poplar borer is a long-horned beetle. It measures about one and one-fourth inches in length, is of a mouse-gray color, irregularly marked with yellow, elongate spots, and the whole is thickly sprinkled with minute black dots. One variety of the species is brown. The larva is yellowish-white and is nearly 2 inches in length. (See Plate LXIV, Fig. 2.)

Life history and habits.—The eggs are deposited beneath the bark through slits made in the surface. The first eggs of the season probably are deposited in July and the process may extend over the two months following. The resulting larvae feed upon the woody tissues of the host, meanwhile discharging through their tunnel entrances large quantities of sawdust-like castings, and when nearly mature are found in large, deep galleries in the tree trunk. In these secure retreats, they transform to the pupal stage, the adults emerging and remaining abroad during July, August and into September. The winter is passed in the larval stage.

Nature of work.—The boring of the trunk of the host not only ruins the wood for lumber purposes, but also so weakens it that the trees frequently break during storms. In addition, the mutilation of the tree tissues invites the entrance of destructive bacteria and fungus spores and these secondary invaders frequently are quite as ruinous as the borer itself. Death of the host is very common. Plate LXIV, Fig. 3, conveys some idea of the character of the injury and a glance at Plate II shows the extended destruction possible by this insect.

Food plants.—Carolina poplar, cottonwood, *Populus tremuloides*, lombardy poplar and willows are the food plants.

Distribution.—This insect is distributed over practically the entire United States and is also reported from Canada.

Control.—Unfortunately little can be done by way of artificially controlling the poplar borer. The larvae are hard to discover in their winding burrows, and thus far no method has been devised to prevent their entrance into the host. Cutting and destroying the infested trees by June 15, at which time those badly infested are most plainly marked because of the abundance of castings, would in some measure curtail the spread of the pest.

THE POPLAR AND WILLOW BORER

(*Cryptorhynchus lapathi* Linn.)

Description.—The poplar and willow borer is in the adult stage a long-snouted weevil measuring from one-third to two-fifths of an inch in length. (See Plate LXV, Fig. 1.) The general body color is very dark gray with the exception of the tips of the wing covers which are pale. The boundary line of these two-color areas is very distinct as indicated by the illustration. The egg is pure white and is found inserted in the corky bark of the host. The larva is footless, grub-like, thick, and is a little less than one-half of an inch in length. The pupa is about one-third of an inch long and is found in a cell in the larval burrow.

Life history and habits (49).—The winter is passed in the larval stage. By mid-June pupation begins and the first adults make their appearance after mid-July, becoming abundant in August and have been observed abroad in New York as late as October 7. About 10 days after emergence mating occurs and the eggs are deposited.

About 3 weeks is spent in the egg stage, and the resulting larvae constitute the over-wintering form. There is but one brood per season.

Nature of work.—The injury is two-fold in nature, the puncturing in the bark of the host by the beetles and the boring by the larvae. The latter is, of course, much more important and is attended with the possibilities of the fungous and bacterial infection such as were described for the preceding species.

The injury is greatest to nursery stock and newly-set trees. In New York instances are on record where large quantities of stock have been rendered almost worthless by this borer and at the Ohio Station the pest interferes seriously with the experimental forestry plots. (See Plate LXV, Fig. 2.)

Food plants.—Doctor Matheson (49) presents the following concerning food plants. "The poplar and willow borer has a fairly wide range of food plants. European writers record it as attacking the following species: Alders, *Alnius viridis* D. C., *A. incana* Willd.,

A. glutinosa Willd.; willows, *Salix caprea* L., *S. viminalis* L., *S. purpurea* L., *S. triandra* L.; poplar, *Populus alba* L.; birch, *Betula* sp. Jack (1897) states that in America all the native willows except the slender-stemmed species are subject to attack. This is confirmed by C. S. Sargent, Director of the Arnold Arboritum at Cambridge, Mass. Of the imported willows the following have been observed injured in the Arnold Arboritum: *Salix alba* L., *S. fragilis* L., *S. bablyonica* Towm., *S. pentandra* Linn."

The following species of poplars are also recorded as host plants: *Populus balsamifera* L., *P. deltoides* Marsh., *P. alba* L. Schoene (1907a) records the following species of willows as host plants: *Salix lucida* Muhl., *S. caprea* L., *S. cordata* Muhl., *S. sericea* Marsh, *S. alba* L., *S. amygdaloides* Anders. In addition two species of birch are known to have been injured, *Betula pumila* L. and *B. nigra* L."

Distribution. This beetle is well-known in Europe and is widely distributed over the northern and eastern section of the United States.

Control.—Doctor Matheson found that treating the trunks of the trees with carbolineum avenarius is a safe and reliable remedy. The liquid is taken in a small receptacle and the workman dips a bit of cotton waste into the liquid and bathes the trunk of the tree. The work should be one during the latter part of March or the first week of April. It is preferable that the work be done on a warm day since the carbolineum spreads better under such conditions.

THE HICKORY BARK BEETLE
(*Scolytus quadrispinosus* Say)

Description.—The hickory bark borer in the adult stage is a tiny, dark-brown beetle about one-fifth of an inch in length.

However, neither the larvae nor adults are often seen unless special search is made by cutting into a dead or dying hickory tree. Usually when a hickory tree is dying and the trunk is seen to have numerous, small, round holes in it, the work is that of this beetle. (See Plate LXVI, Fig. 1.)

Life history, habits and injury.—Doctor Felt summarizes the life history of this species as follows: "The beetles appear from the last of June to the last of July and may be found in New York State up to the middle of August. They bore through young twigs, terminal buds and green nuts, evidently for food, and in this manner they frequently cause the wilting of leaves and the death of twigs. They attack the bark of the trunk and the larger branches

in July, each female making a vertical gallery an inch or more in length and along the sides of which she deposits in small notches, 20 to 50 eggs. The parental galleries are frequently very regularly placed on the tree one above another. The eggs soon hatch and the grubs work in the tissues at first at nearly right angles to the primary galleries, but those at the extremeties soon diverge from the others till they run nearly parallel with the wood fibres. The larval galleries rarely cross each other. Winter is passed by the grubs in a nearly full-grown condition. They transform to pupa during the last of May and the beetles appear about a month later." This species has entered Ohio from the eastern border and is gradually working westward. It may be said to be sweeping the hickories before it as it progresses. (See Plate LXVI, Fig. 2.)

Food plants.—Bitternut, shellbark and pignut hickory and probably pecan are the food plants.

Distribution.—This insect ranges over the entire section of the United States east of the Mississippi River. It is also reported from Canada. In Ohio, it is particularly prevalent in the northeastern section. In Youngstown great damage has been done in the parks by this insect through the destruction of the hickories. The area of severe injury seems to be working westward gradually.

Natural enemies.—Four hymenopterous parasites have been recorded from the hickory bark beetle: *Spathius trifasciata* Riley, *S. unifasciatus* Ashm., *Lysitermus scolyticida* Ashm., and *Bracon scolytivorus* Cress. A beetle, *Clerus ichneumoneus* Fabr., preys upon this species.

Control.—Little is to be done by way of destroying the hickory bark borer after it once gains access to the tree. About the only thing of a practical nature to be done is to remove and destroy trees as soon as they are known to be attacked, or in case only parts are invaded by the beetles to remove those parts.

THE PIGEON TREMEX
(*Tremex columba* Linn.)

Description.—Diseased or dead trees are preferred by this insect, and although rather plentiful it is not of great economic importance. However, the insects quite frequently are observed searching about such trees and it is forthwith assumed that they are responsible for the trees' condition.

The adult pigeon tremex is a beautiful four-winged, wasp-like creature having a wing expanse of about two and one-half inches. The tip of the abdomen is adorned by an appendage which the insect

uses in boring holes into the solid wood for oviposition. The general body color is brown with distinct yellow markings on the abdomen. (See Plate LXX, Fig. 3.)

Life history.—The adults of the pigeon tremex emerge from the trunk of the host through holes almost as large as a lead pencil. Eggs are deposited in the manner previously described. The resulting larvae eat their way into the wood. Since they ultimately become 2 inches or more in length they are capable of much injury to the host. It is not known whether more than 1 year is required to complete the life cycle.

Food plants.—Maple is the favorite food plant, but in addition to this host, apple, pear, beech, oak, sycamore and probably others are subject to attack.

Distribution.—The pigeon tremex is found throughout Ohio and is reported from many of the neighboring states and Canada.

Natural enemy.—This insect has one very important parasitic enemy, *Thalessa lunator* Fabr., sometimes known as the lunate long sting. This is a magnificent wasp-like insect having a body about one and one-half inches long; attached near the tip of the abdomen is a slender hair-like appendage about 3 inches long, and though fragile in appearance the insect is able to drill the hardest wood with it. During the drilling process the ovipositor describes a graceful loop or arch over the back. Quite commonly the ovipositor becomes jammed in the wood and the insect perishes.

By means of its drilling ovipositor, the long sting penetrates the burrow of the pigeon tremex, deposits an egg therein which later hatches into a grub that attacks the larva of the tremex.

Control.—Since the pigeon tremex prefers weakened, dying or dead trees, steps leading to the maintenance of a vigorous tree growth constitute one of the best control measures. Trees badly attacked should be removed.

THE MAPLE BORER

(*Synanthedon acerni* Clem.)

Description.—The maple borer is also called the maple sesian and like many of the boring insects the rather characteristic work is better known than is the insect itself. When the insect once is recognized, however, it never will be forgotten. In the adult stage the maple borer is a particularly beautiful wasp-like moth. The wings are composed mainly of a clear membrane tinged with yellow and hyaline; the head is red as is also a conspicuous fan-like plume at the tip of the body. The thorax and legs are a decided yellow. The female moth measures about 1 inch across its expanded wings

and the male about three-fourths of an inch. The caterpillar is about one-fourth of an inch long and has a conspicuously reddish brown head.

Life history and habits.—The moths abound in very early summer and deposit their eggs on the bark of the tree, preferably around the roughened area of wounds and where branches have broken off. After a short time the eggs hatch and the boring larvae begin feeding upon the bark and sapwood, meantime throwing out over the wound characteristic brown castings which form one of the recognition marks of the species. The following spring the caterpillar pupates in its burrow, and later the chrysalid wriggles out until the frontal half of the body extrudes from the burrow. With the pupa in this position, the moth escapes, leaving the brown pupal shell plainly exposed.

Nature of work.—The boring larvae of this pest not only devitalize the host, but render it far more susceptible to injury by storms. Moreover, the corresponding swelling of the tissues into gall-like or cankerous structures at the point of attack on the host, detract seriously from the tree's natural beauty. This type of injury is particularly noticeable when the upper limbs become badly infested. (See Plate LXVII, Figs. 1 and 2.)

Food plants.—Both hard and soft maple are hosts of this species.

Distribution.—This insect is found throughout Ohio and occurs in many other sections of the eastern United States and as far west as Nebraska.

Natural enemies.—Since the caterpillars rarely bore deep into the wood of the host, woodpeckers find them an important source of food and constitute the principal natural check of this insect.

Control.—Since the moths prefer roughened areas for egg laying, protecting the trees from mechanical injury by horses and other agencies is an important preventive measure. With young trees it is practicable to dig out and destroy the caterpillars in late fall or early spring, afterwards treating the wounds with grafting wax. The carbolineum treatment found by Matheson to be effective against the willow and poplar borer might be found satisfactory for this species if applied about midsummer.

THE WHITE PINE WEEVIL

(*Pissodes strobi* Peck)

Description.—The white pine weevil in the adult stage is a hard, oblong beetle about one-fourth of an inch in length. The upper portions are reddish-brown to dark brown in color with

the exception of a whitish spot a little distant from the end of each wing cover. The sides of the body and legs are mingled with white. The beak is robust, curved and is almost equal in length to the thorax. (See Plate LXVIII, Fig. 1a.)

The white, footless, grub-like larva is found beneath the bark of the host, usually in greatest numbers in the terminal 2 or 3 feet of the central branch. They are a little more than one-fourth of an inch in length when full grown. (See Plate LXVIII, Fig. 1b.)

The pupa is about the size of the beetle and when newly formed is creamy white in color, excepting the eyes and tips of the mandibles which are brown. Later the appendages take on a varying amount of brown coloration. (See Plate LXVIII, Fig. 1c.)

Life history and habits.—The winter is passed by the beetles, presumably under ground or at least within the shelter of the refuse of the forest floor. In early May they emerge and during the day may be found clustered head downward at the tip of the developing terminal shoot of the host. They feed for a time upon the bark of the leading shoot and a little later cut neat punctures (See Plate LXVIII, Fig. 2) in it by means of their long beaks and deposit their eggs therein. After a few days the eggs hatch and the resulting larvae begin feeding inward and downward, riddling the tissues of the shoot as they progress, particularly if there is a considerable number of them.

By early August, larval growth has been completed and after constructing neat cells lined with excelsior-like material within the galleries in which they have been feeding, the larvae transform to the pupal stage. (See Plate LXVIII, Fig. 3.) After resting a short time as pupae the insects transform to the adult or beetle stage. A neat, round hole is eaten through the confining wall of the host and the beetle emerges. (See Plate LXVIII, Fig. 4.) It is likely that during the period between the emergence of the beetles from their pupal cells and their retreat into winter quarters that the greatest spread of the species takes place.

Nature of work.—The nature of injury caused by this beetle is of two types. The beetles after leaving their winter quarters in the spring feed upon the tender terminal shoot of the host and cause a heavy exudation of sap. The second and far more serious injury, however, results from the larvae feeding within the tetrminal shoot of the host. As stated previously the grubs tunnel downward and inward and since considerable numbers may occupy one shoot, the attack is almost invariably fatal to it. As a result of the killing of the central leader, the host is badly stunted and deformed and its

utility either as an ornament or for commercial purposes is nearly destroyed. (See Plate LXIX, Figs. 1, 2 and 3.)

Food plants.—The white pine is the preferred host, and is injured more severely than any other, but all of our native pines are subject to attack as are also some of the spruces.

Distribution.—The white pine weevil occupies practically the entire range of the white pine which extends northward from South Carolina to New Brunswick and Canada and westward to include Wisconsin and part of Minnesota.

Natural enemies.—The white pine weevil is preyed upon in the larval and pupal stages by a number of birds which tear open the sides of the cells and destroy the occupant, and the emerged beetles also are picked up. The young of beetles belonging to the family Tenebrionidae are said also to destroy the larvae.

Bracon pissodis Ashm. and *Spathius brachyrus* Ashm. have been bred by others from the white pine weevil and the writer has reared two parasites of which the first, *Epialtes comstockii* Cress, was determined by Mr. R. A. Cushman, and the second, *Eurotyma* sp., was determined by Mr. A. B. Gahan, of the Bureau of Entomology of the United States Department of Agriculture.

Control.—Efforts on the part of entomologists to devise a simple and effective control measure have met with but partial success. Two give some promise. The first consists in collecting the beetles when they collect upon the tip of the central branch in early spring. As described in a previous paragraph, the beetles leave their hibernating quarters in early May and collect upon the tip of the leader. When disturbed they have a tendency to drop, hence they may be collected with considerable facility if the branch be bent over the top of a collecting net at least 15 inches in diameter and sharply jarred. A good method of procedure consists in holding the handle of the net in one hand and a lath in the other. By means of the lath the leader is bent over the mouth of the net and lightly tapped. It has been found that if the collecting is repeated at intervals of 3 or 4 days for three or four periods, the injury by the insect may be considerably decreased. Moreover, the four collections should be done for something in the neighborhood of $1.50 to $2 per acre.

The second control method consists in spraying the tip of the central leader with a solution of arsenate of lead, using the material at the rate of 6 pounds of paste or 3 pounds of powder to 50 gallons of water. This application should be made not later than May 1.

THE BRONZE BIRCH BORER
(*Agrilus anxius* Gory)

Description.—The bronze birch borer is a comparative newcomer in Ohio, but the record of its destructiveness since its entrance into the state is quite as disturbing to the lovers of the beautiful white birch and other birches as well as to those in other states who have known the pest for a longer period.

The adult of the bronze birch borer is a slender beetle about one-half of an inch long, olive-bronze in color; the larva or borer is a little longer, measuring about three-fourths of an inch. It is footless, slender, flattened and creamy-white in color. Both adult and larva are shown in Plate LXX, Fig. 2. The insect is best known, however, not from its own characteristics and appearance but by reason of its work in birches and particularly the white birch.

Life history and habits.—The insect passes the winter in the full-grown larval stage in a cell made in the wood of the host not far from the bark. In early spring of the following year the larvae change to pupae and a little later the adults begin to emerge. As to the exact date of the appearance of the adults, however, there seems to be some variation. Some diversity of opinion exists among entomologists though it may be stated that the adults probably appear in May or June, and in all likelihood the largest numbers appear during the latter month. This point as will be noted later is of considerable importance in the control of the species.

The eggs are laid in crevices in the bark in June and the larvae upon hatching bore into the bark of the host. At first the tunnel lies close under the bark, but as the work of the feeding larva continues, the burrow is extended without any particular definiteness as to form or direction, now deeper into the wood; now up near the bark; extending this direction and that until it becomes a much convoluted affair. The general result is the riddling of the tissues of the host in the immediate vicinity of the burrow and the formation of a dark reddish-brown spot above on the bark.

Larval growth is completed by October and the insect goes into hibernation.

Nature of work.—As previously indicated this insect is a borer. It starts in the upper branches of the host and as a direct result of the riddling by the feeding larva the upper part of the tree dies. The dying of the top of a prized ornamental is in many instances the first indication of the presence of the pest in the vicinity. Later, through the continued activity of the insect the entire tree dies.

Food plants.—The white birch (*Betula alba*) and its cut-leaved weeping variety (*Pendula laciniata*) are the preferred hosts, and the following additional species of birch have been recorded: black birch (*B. lenta*), yellow birch (*B. lutea*) and canoe birch (*B. papyrifera*). There is a possibility that the insect may survive in willow and the adult beetles have been taken on cut poplars.

Distribution.—According to Slingerland (51) writing 12 years ago, "This bronze birch borer is an American insect and is widely distributed throughout the northern United States and Canada. It has been recorded from New Hampshire and Massachusetts, westward through Connecticut, New Jersey, New York, Pennsylvania, Virginia, Quebec and Ontario in Canada, Michigan and Illinois to Colorado."

A few years ago, probably about half a dozen, the insect entered Ohio at Toledo from Michigan, and is gradually working southward. This fact together with that that the insect is known to be well established in Buffalo and western New York to the east indicates that it is only a matter of time until the State, and particularly the northern part will be generally infested.

Natural enemies.—Woodpeckers are known to be of great value in searching out and destroying the bronzed birch borer before the insect escapes from the tree. Slingerland (51) reports breeding out a parasitic Chalcid fly, *Phasgonophora sulcata* Westwood, from this pest and since the parasite is widely distributed it would seem that it may be of considerable natural value in controlling the species.

Control.—No method is known by which a tree may be protected in the presence of the adults of the bronze birch borer. The only suggestions we are able to make at this time by way of minimizing the injury, is the practice of sanitation with the thought of reducing the numbers of egg-laying beetles. All trees known to be infested with the bronze birch borer should be cut and burned before the last of April to prevent the emergence of the adults. The cutting out of the dead top of an affected tree is a mistake, for not only is the uncut remainder of no value from the esthetic standpoint, but when the infestation is sufficiently severe to cause the death of the top, the remainder of the tree usually will be so badly infested that it will merely serve as a breeding place of infection.

THE MAPLE AND OAK TWIG PRUNER

(*Elaphidion villosum* Fabr.)

Description.—Perhaps as much mystery surrounds the activi- of this twig pruning insect as any other shade tree or forest pest.

In the fall of the year it will be noted that twigs a foot or more in length are dropping from the tree under attack and these twigs upon examination will be found with the end so neatly and squarely smoothed off as to appear cut with a sharp chisel. Upon examination the pruned twig will be found to bear a tunnel and within the tunnel is a slender grub, white in color with the exception of the jaws which are brown. The adult is a slender grayish-yellow somewhat mottled beetle, a little over one-half of an inch in length. (See Plate LXX, Fig. 1.)

Life history and habits.—Doctor Felt has recorded the life history and habits of this species as follows: "The adult is said to deposit an egg in July in one of the smaller twigs. The young larva feeds for a time in the softer tissues under the bark, packing its burrow with castings and working toward the base of the twig. Later it bores along the center of the limb, making a more or less oval channel. In the early fall our borer quietly eats away a large portion of the woody fiber, plugs the end of the burrow with castings and waits for a high wind to break off the nearly-severed branch. In this manner the larva reaches the ground in safety. Late in the fall or in the early spring the change to the pupa takes place and the transformation to the perfect insect occurs in the spring, the beetles emerging from the limbs in June and continuing abroad until September. Occasionally the insect completes its changes in the portion of the limb remaining on the tree; it as a rule drops with the severed branch."

Nature of work.—As the name indicates and in the manner the previous paragraph depicts the maple and oak twig pruner is a destroyer of the twigs and small branches of the host, and this process constitutes the prime injury inflicted by the species. In a secondary manner, however, this twig pruner is injurious because the fallen branches attract other wood-boring beetles, some of which may attack the living wood of the host. Ordinarily, the pruning of the twigs is no very great detriment to the tree since the twigs rarely are destroyed in any very great numbers. However, in December, 1917, the writer observed extreme injury to elms along the Arkansas River in southern Kansas where at least 50 percent of the smaller branches were pruned and had fallen to make a veritable mat beneath the tree—apparently the work of this species—although I did not have an opportunity to rear the adult form.

The falling of the pruned twigs on lawns and in parks sometimes constitutes a source of considerable annoyance. It is no uncommon thing to hear that squirrels are blamed for the work.

Food plants.—In Ohio, oaks serve as the chief host but it has been reported on maple, apple, pear, plum, peach, grape, quince, orange, hickory, chestnut, locust, sassafras and sumac. In addition to this list, it is possible that elm should be added as well as several other hosts but at the present time the records are not sufficiently conclusive to warrant doing so.

Distribution.—This insect not only is distributed throughout the state but also occupies a wide range of territory throughout the eastern and central sections of the United States.

Natural enemies.—Birds are the chief natural enemies of this species. The woodpeckers, of course, are of greatest value and in addition the chickadee and blue jay may be mentioned.

Control.—No method is known whereby the beetles may be prevented from laying their eggs in the twigs. Something may be accomplished, however, by way of controlling the species if all fallen twigs be collected before the beetles emerge in the spring. In parks and on lawns this practice is highly commendable, particularly if no forests or woodlots are in the immediate vicinity.

THE CARPENTER WORM
(*Prionoxystus robiniae* Peck)

Description.—The carpenter worm is one of the largest of the destructive borers, the galleries which the well-grown caterpillar makes in the heartwood of the host sometimes measuring over 1 inch in diameter.

The mature insect is a beautiful moth, the female measuring about 3 inches across her expanded wings. The general color is dark gray, mottled with a lighter shade. The hind wings show less mottling and sometimes are faintly tinted with yellow. The body is long, cylindrical and heavy, especially when distended with eggs. (See Plate LXVII, Fig. 3.)

The male is smaller, measuring about 2 inches across his expanded wings. In general he resembles the female. The fore wings are slightly mottled but in general are darker; the hind wings, however, are quite different due to the presence of a large yellow or orange area along the outer margin.

Doctor Felt says: "The eggs have a broadly oval form and are about one-half the size of a grain of wheat, being about one-tenth of an inch in length and about three-fourths of an inch in diameter. They are of a dirty whitish color with one of the ends black, and when highly magnified, the surface is seen to be finely reticulated or marked by rows of slightly impressed dots."

When full grown the caterpillar is about 2½ inches in length. Usually it is almost white with a pinkish tint. The head is dark-brown and brownish tubercles are found scattered over the body segments.

The pupa is about 1½ inches in length, brownish in color and bears a considerable number of strong-toothed processes.

Life history and habits.—The eggs are deposited in June or early July in crevices or abrasions in the bark of the host, and the larvae upon hatching bore into the wood. Unlike many other borers the greater part of the larva's activities are expended upon the heartwood of the host and it is because of this injury to the valuable part of the tree that the loss by this species amounts to what it does.

It is generally supposed that 3 years are required to complete the life cycle of this pest.

Nature of work.—The boring by the larva causes the formation of unsightly deformities on the host and occasionally the tree is broken during high winds at the point of injury; but these are insignificant when compared with the losses in the lowered quality of the lumber and other products which the activities of this pest bring about.

The set posts in almost any fence row, particularly in the southern part of the State, bear evidences of the work of this insect. Posts so tunnelled not only rot more quickly than do sound posts, but are more easily broken over.

Food plants.—Black locust is injured to a greater extent than any other species in Ohio. It sometimes harms other trees as well and has been reported upon the following hosts: ash, maples, cottonwood, willow, chestnut and oak.

Distribution.—This insect occurs throughout Ohio and is found throughout the greater part of the United States, particularly east of the Rocky Mountains.

Natural enemies.—Since the eggs are large and conspicuous it is possible that birds are of considerable economic value in picking them up and destroying them before they have time to hatch.

Control.—Since the adults choose abrasions and other roughened areas on the trees, the careful smoothing up of such areas before June might be of some benefit. This treatment may be supplemented by the destruction of the boring larvae by injecting carbon bisulphide in the tunnels. The foregoing suggestions apply of course only to prized shade or ornamental trees.

ERRATA

Page 265, line 2.
For *Basiloma* read *Basilona*.
Page 300, line 32.
For *Eucyrtus* read *Encyrtus*.

PLATE I

UNSATISFACTORY AND SATISFACTORY TYPES OF THE TREE BELT

Fig. 1.—A narrow tree belt. When the space allotted to the trees is narrow, not only do the trees suffer from insufficient aeration of the soil and inadequate water, but the arrangement necessitates placing the tree near the edge of the paving where it is particularly susceptible to injury by horses and other agencies. Nearly every tree in this row was injured in one way or another and their growth and appearance as a result, was very unsatisfactory. A better arrangement of this tree belt and sidewalk, since so little space was allotted for trees when the street was laid out, would have been to have placed the sidewalk next to the curbing and to have planted the trees in the resulting wider tree belt between sidwalk and fence.

Fig. 2.—This tree belt, almost 8 feet wide, allows a better opportunity for tree development, and at the same time removes the trees a sufficient distance from the pavement that the danger of injury by horses is almost negligible. Little temptation exists here to use the trees as hitching posts.

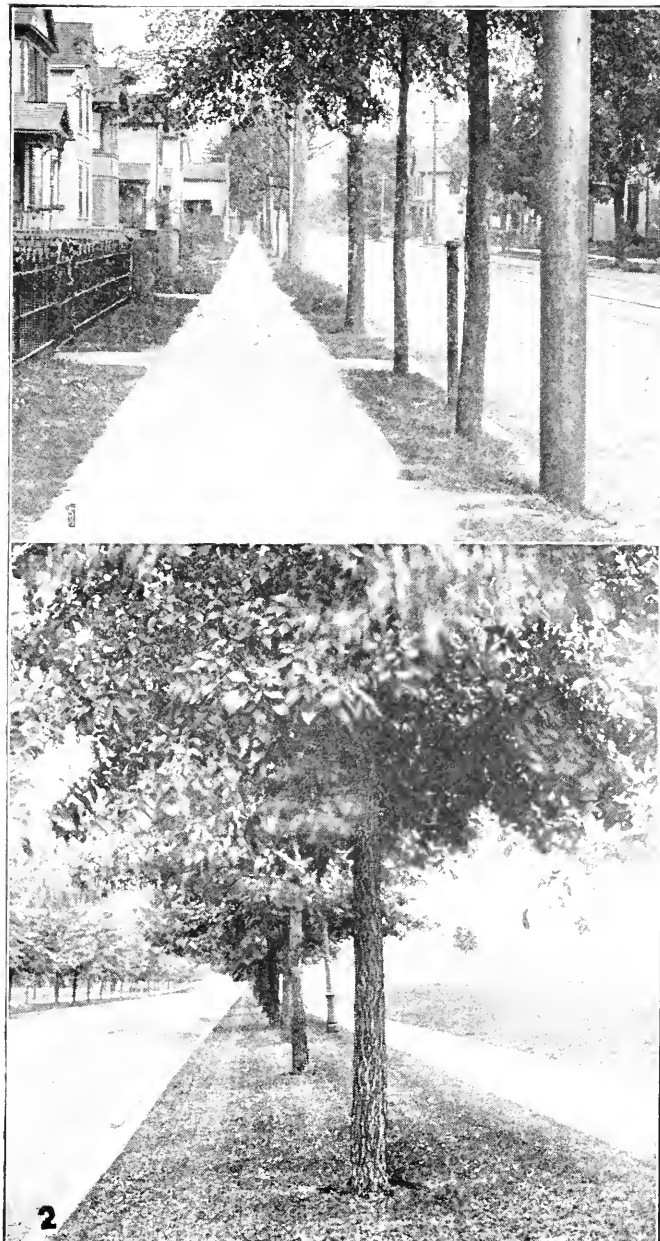

PLATE II

EXTENSIVE AREAS DEVOTED TO A SINGLE SPECIES FREQUENTLY PROVE UNSATISFACTORY

Carolina poplar, Cincinnati, Ohio, killed by the poplar borer (*Saperda calcarata*). This picture illustrates the inadvisability of planting large areas to a single species. The borer gained a foothold in this planting and practically every tree was killed by it. Pure plantings in many cases invite insect disasters and in the event the planting is destroyed, the loss is keenly felt. Mixed plantings are less likely to suffer complete destruction by a single invader.

PLATE III

TREES GROWING IN EXPOSED SITUATIONS SHOULD BE PROTECTED

Fig. 1.—Unprotected trees, growing near the pavement are very likely to be gnawed by horses. A wound made when the tree is young may be kept open and enlarged by subsequent gnawing and injury to the tender growing edges until ultimately the tree is ruined. The exposed trunk of the tree decays in time and without the protective bark covering is particularly susceptible to attack by boring insects.

Fig. 2.—Although placed in a difficult situation this young sycamore is making good progress. The trunk is protected by a guard made from 15-inch galvanized hardware cloth constructed from 16-gauge wire and having half-inch meshes. This wire is cut in 6-foot lengths and shaped by being run through a stove-pipe shaping machine. This is one of the best types of tree protector known and is, during normal conditions, not very expensive. It may be expanded as the tree trunk increases in diameter. This protector far excels the more expensive ornate ones. Note also the iron grating set in the pavement which permits soil aeration, the access of water and applications of pulverized fertilizer.


1
2

PLATE IV

Fig. 1.—A hardware cloth tree protector expanded to accommodate the growing trunk of the tree and secured by two short lengths of copper wire. Note the unprotected part of the trunk is toward the sidewalk and not toward the street. An area should be left unpaved about the base of the tree, in order to afford it an opportunity for development and at the same time to prevent injury to the walk by the roots heaving it up.

Fig. 2.—The danger of injury to tree trunks is considerable in the immediate vicinity of building operations. These large trees are in front of property upon which there was being erected a large school building. For protecting large trees under such conditions, the hardware cloth guards are not adequate but a more sturdy type should be used.

2

1

PLATE V

TREE BUTCHERY AND GAS INJURY

Fig. 1.—The butchery practiced by aerial linemen in order to stop interference with their wires is an important source of injury to trees in cities. Trees so beheaded rarely thrive afterwards and their natural beauty is forever ruined. A better scheme is to adopt the cable system either aerial or subterranean and to run all necessary aerial lines through the alleys, where they interfere but little with the trees.

Fig. 2.—A row of trees killed by a leaking natural gas main, Akron, Ohio. The first evidence of gas injury usually is a wilting of the leaves, and may or may not be accompanied by discoloration. If trees in the vicinity of gas lines are noticed suddenly to become sickly, an immediate examination should be made and the leak if present should be stopped. As a rule, however, trees do not survive if injured sufficiently for the symptoms to be indicated by the wilting foliage. Moreover, there is little to be done by way of counteracting gas injury, about the only thing being that of digging up and aerating the soil.

PLATE V

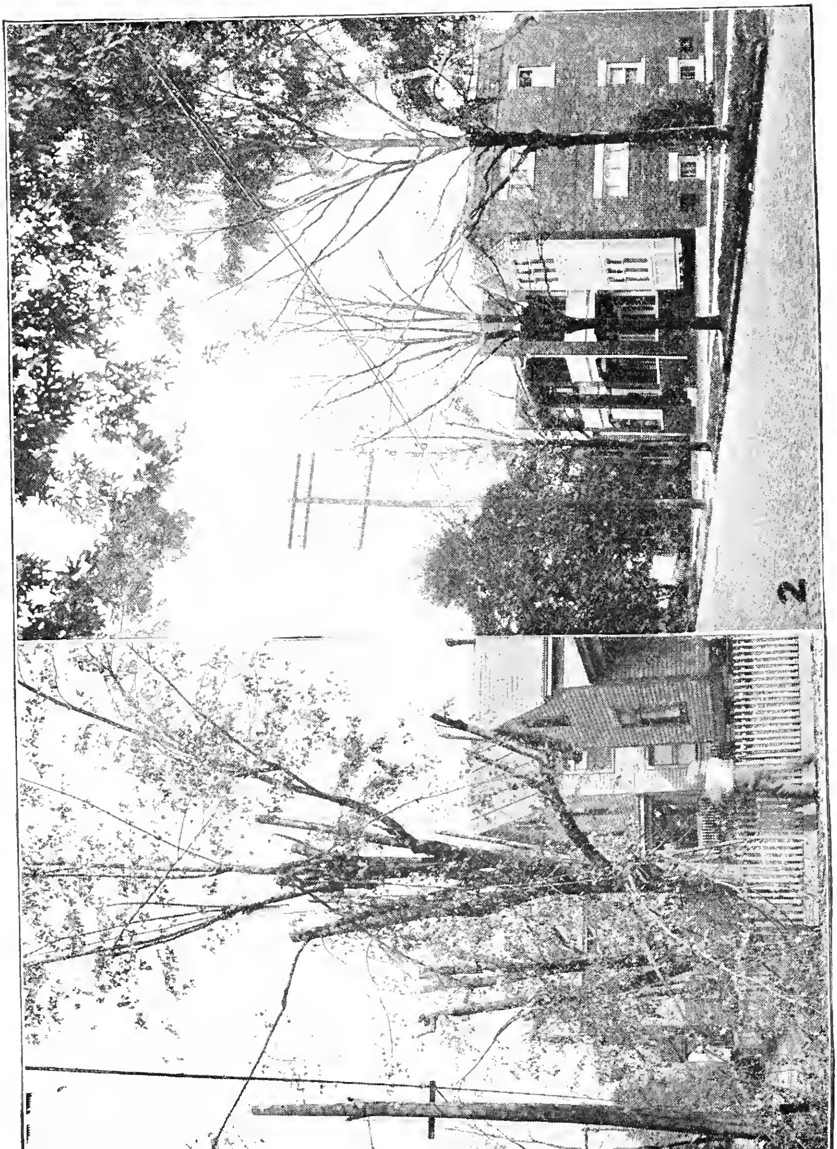

PLATE VI

WHERE SPRAYING IS IMPRACTICABLE

A white ash grove badly infested with oyster shell bark louse (*Lepidosaphes ulmi*). In this instance spraying to control the scale was not practicable because of the height of the trees and the woodlot therefore was cut prematurely.

PLATE VII

SMALL HAND SPRAYERS

Fig. 1.—A small-capacity spraying machine of the fog or mist class. Hand-driven sprayers have a very limited field of usefulness in shade tree spraying operations.

Fig. 2.—One of four machines used by the City of Cleveland in shade tree spraying work 15 years ago. It would require about a hundred of these to cover the ground which her one modern solid-stream sprayer now covers and the work would not be done as well.

PLATE VII

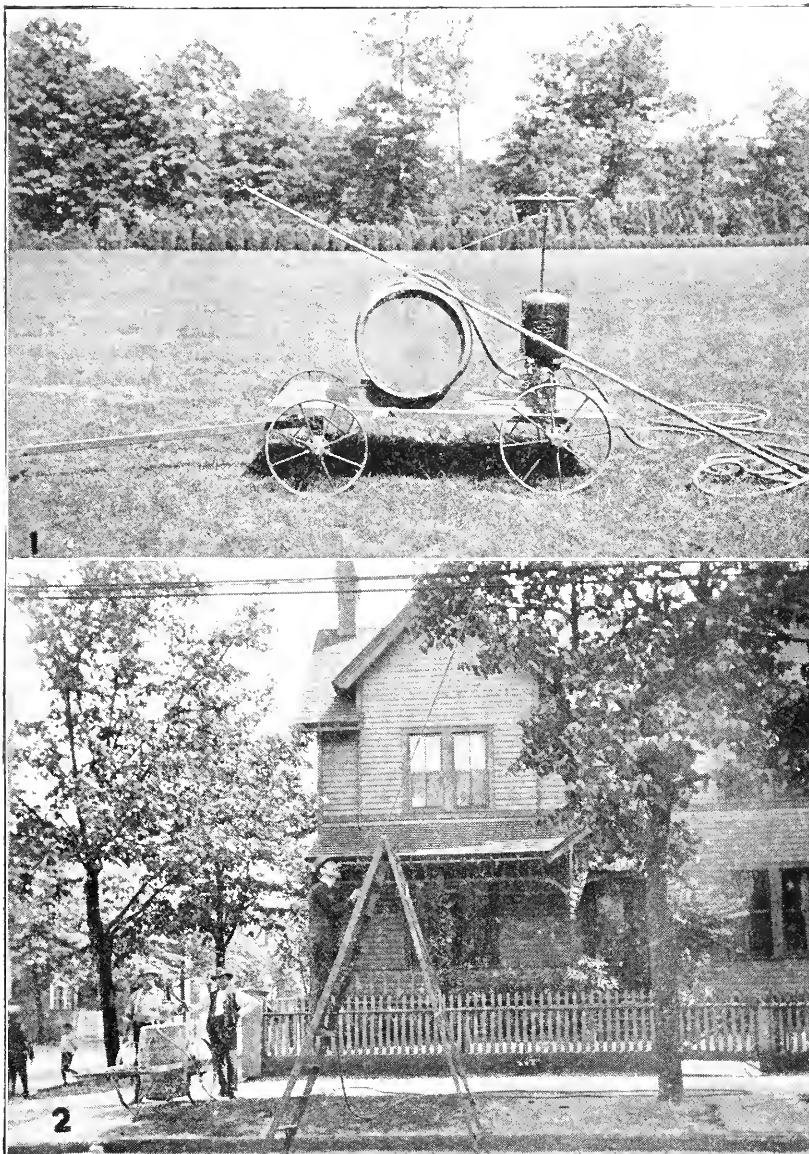

PLATE VIII

A POWER SPRAYER OF THE MIST OR FOG CLASS

This is one of the machines operated by the Board of Park Commissioners of Cincinnati, Ohio. Sprayers of this type have a considerable field of usefulness in Ohio, particularly where shrubbery and low trees in parks require annual treatment for scale. Note the sturdy construction of the running-gears, an important detail when used on uneven city pavements.

PLATE VIII

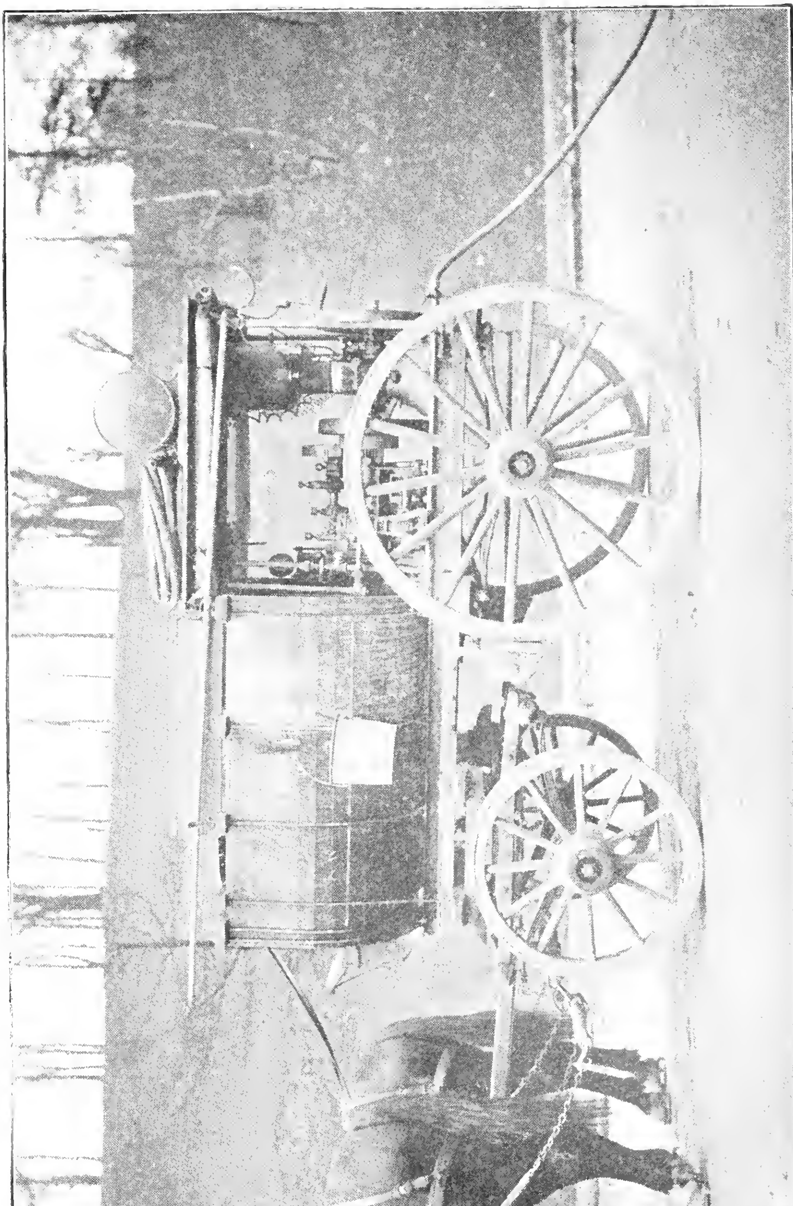

PLATE IX

SOLID STREAM SPRAYERS

Fig. 1.—A spraying machine of the solid stream type. Such machines will throw a stream nearly 100 feet in the air, hence the tallest trees may be sprayed with the operator standing on the ground. Because of the rapidity with which work may be done, thus minimizing labor costs and the more perfect work possible with machines of this class, they are by all odds the most satisfactory for use in shade, park and forest tree spraying. Two machines of this type are in use in Ohio, one by the city of Cleveland and one by the village of Bratenahl, a suburb of Cleveland.

Photograph, Fitzhenry-Guptill Co.

Fig. 2.—A motor-driven solid stream sprayer. The motor in the chassis not only furnishes power for traction but runs the spray pump as well; moreover, the spray pump may be engaged as the truck moves along, thus affording a very efficient and speedy method for spraying low-lying shrubbery and bushes along highways. When the sprayer is not needed it may be disengaged and demounted and the truck used for other purposes. This machine is used by the State Forester's Department of Massachusetts in gipsy and brown tail moth control.

Photograph, Fitzhenry-Guptill Co.

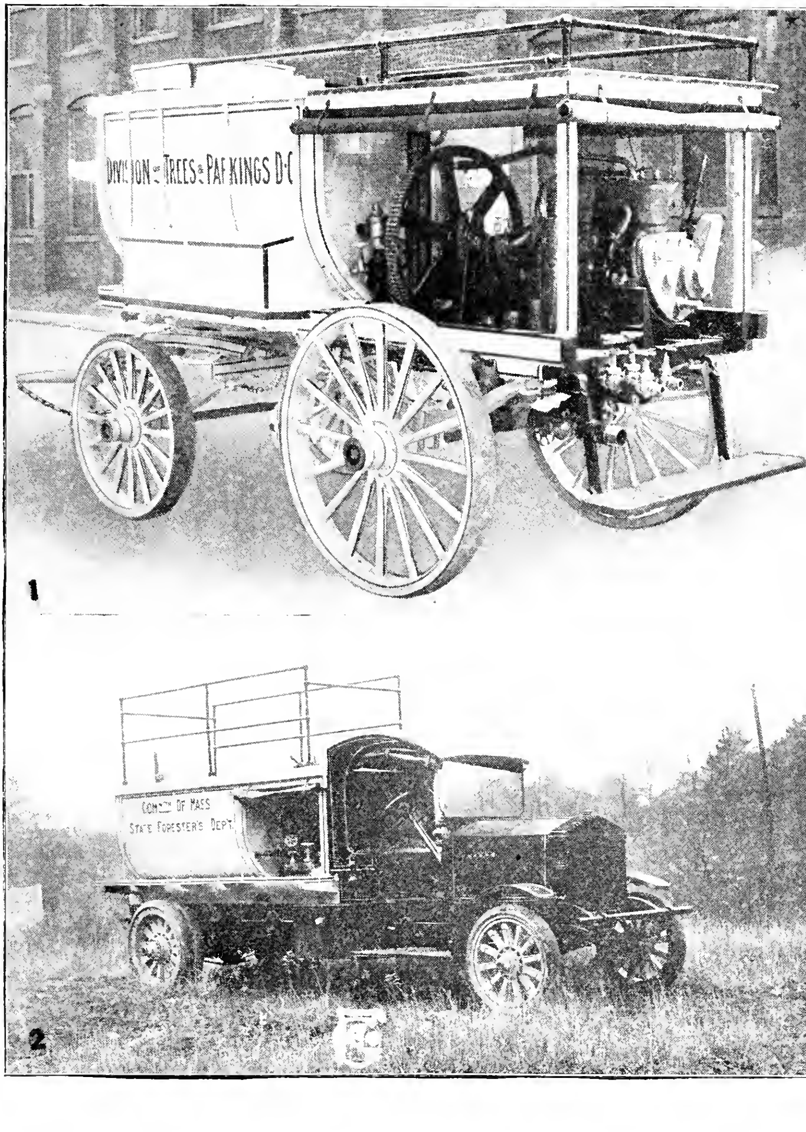
1
STATE FORESTER'S DEPT.
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PLATE X

SOLID STREAM SPRAYERS IN ACTION

Fig. 1.—The solid-stream sprayer in use on street trees. The spray is much more easily directed by the solid stream method than by the mist method and at the same time the operators are better able a protect the nearby dwellings from the drift of the finely divided liquid.

Photograph, Fitzhenry-Guptill Co.

Fig. 2.—The solid-stream sprayer in use on roadside trees.

PLATE X

PLATE XI

THE SOLID STREAM SPRAY WITHOUT AND WITH THE SPREADER ATTACHMENT

Fig. 1.—One of the motor truck sprayers used by the Bureau of Entomology of the United States Department of Agriculture in the gipsy and brown tail moth work in New England. Note the number of men required as hose bearers when extremely long lines of hose are used.

Photograph, Fitzhenry-Guptill Co.

Fig. 2.—The same machine as shown in Fig. 1, but having the spreader attachment on the nozzle in place for spraying the lower branches of the trees.

Photograph, Fitzhenry-Guptill Co.

PLATE XI

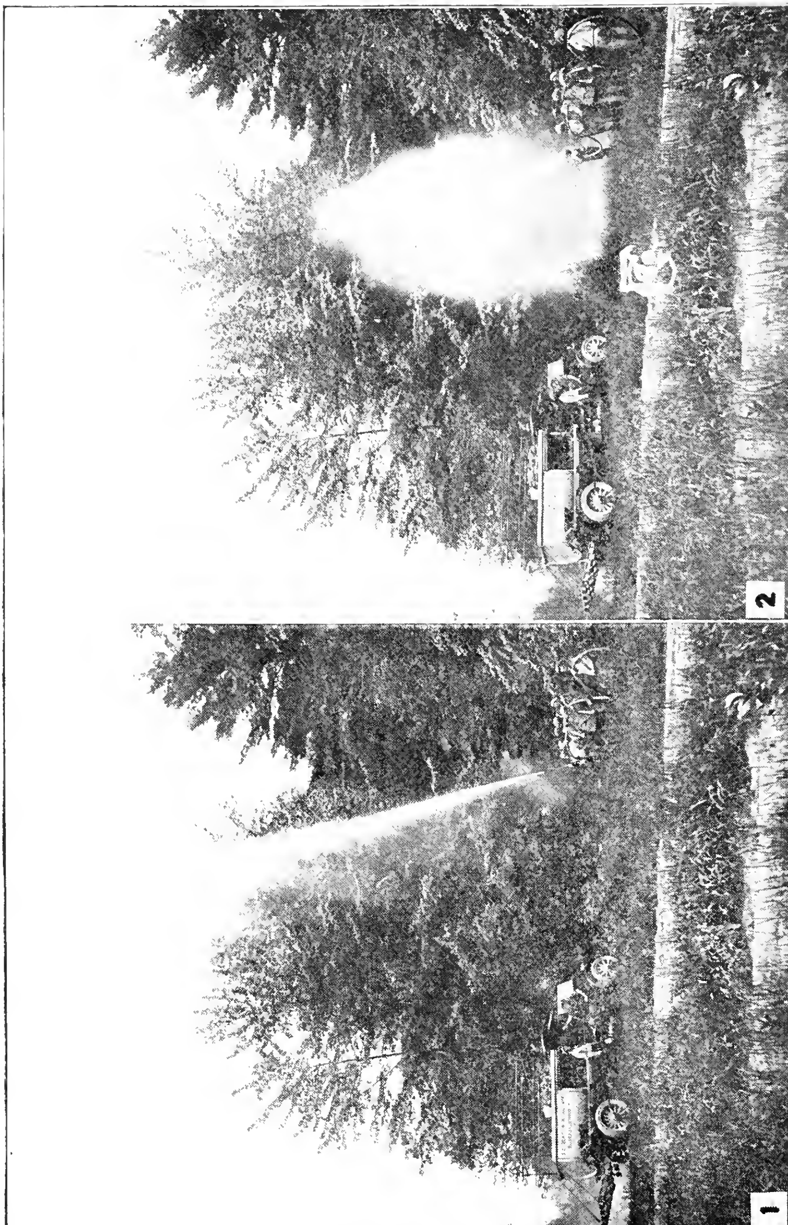

PLATE XII

THE SOLID STREAM SPRAY WITHOUT AND WITH THE SPREADER ATTACHMENT

Fig. 1.—The solid-stream sprayer at work in woodlots and forests. In this instance the nozzle was 1,500 feet away from the spraying machine. Occasionally lines of hose 1 mile in length are used. The Bureau of Entomology of the United States Department of Agriculture has sprayed with one machine in 1 day's time 21 acres of woodlot consisting of trees averaging 60 to 70 feet in height. From 12 to 15 acres is the average day's work, however.

Fig. 2.—The solid-stream sprayer with the M. A. C. spreader in place. See Plate XIV, Fig. 2, for an illustration of this spreader.

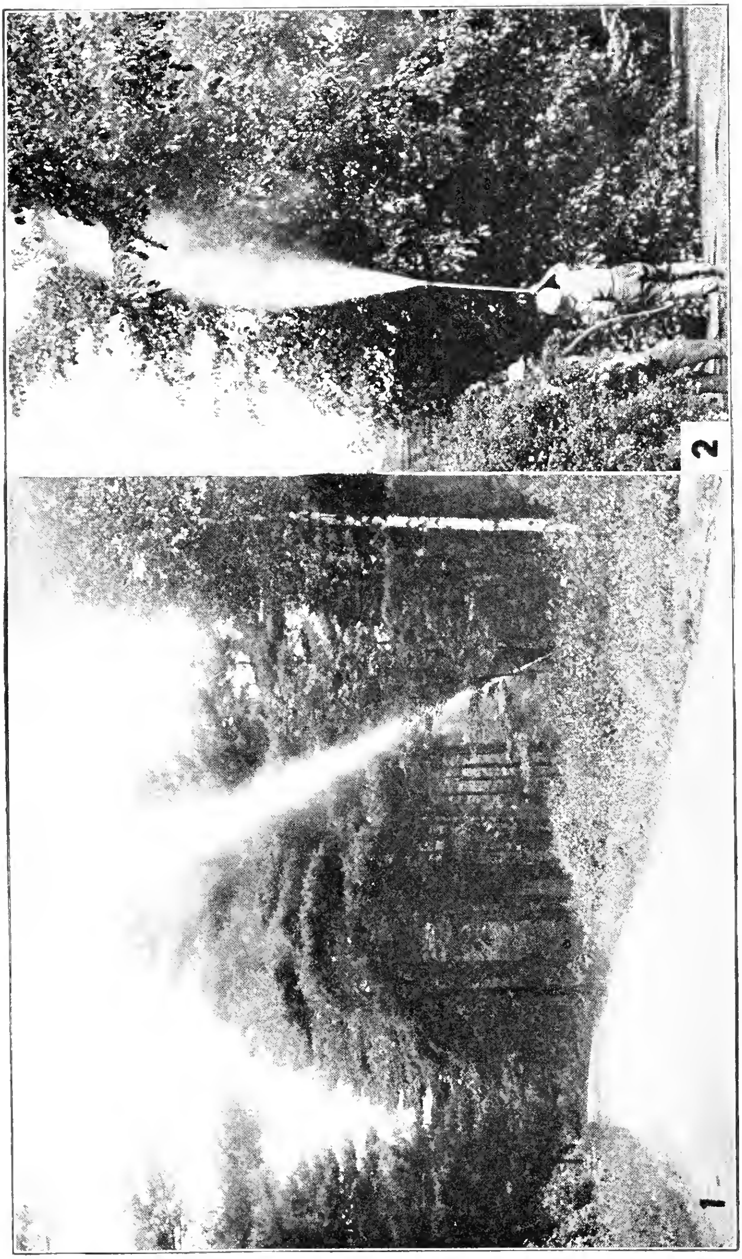
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PLATE XIII

THE NEW ENGLAND WAY

Fig. 1.—The motor truck, solid-stream sprayer spraying roadsides.
Photograph, Fitzhenry-Guptill Co.

Fig. 2.—One spraying of arsenate of lead produced this result in this New England woodland. By the solid stream method, the Bureau of Entomology of the United States Department of Agriculture has found that woodlands may be sprayed at a cost of about $5.50 per acre when large areas are to be sprayed. Spraying small areas is of course more expensive.
Photograph, Fitzhenry-Guptill Co.


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PLATE XIV

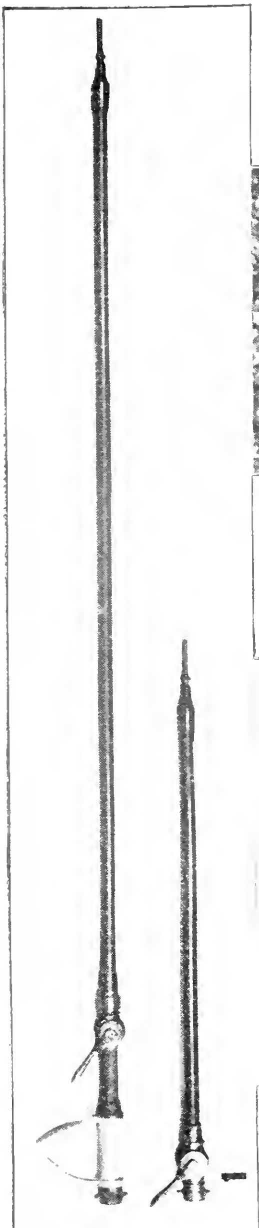
ACCESSORIES

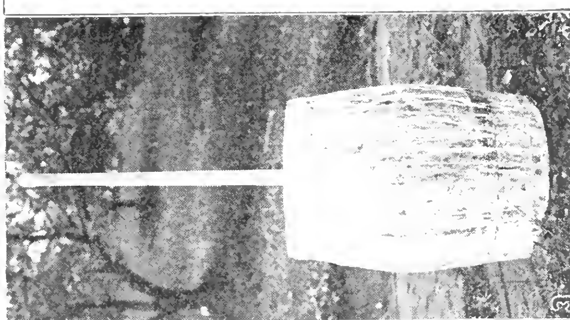
Fig. 1.—Two types of the Worthley nozzle, used on many of the solid-stream sprayers of the New England states. The extreme tip is removable and may be had in assorted sizes having bores of five-sixteenths, one-fourth, three-sixteenths and one-eighth inch. The larger the aperture, the greater the capacity and the greater the height of spray possible to throw.

Fig. 2.—The M. A. C. spreader sometimes used in connection with the Worthley tip. The pin A centers the stream rushing through aperture C and breaks it up. By means of the handle B, the pin A may be thrown to one side and thus permit solid stream work. The M. A. C. spreader is now displaced in a large measure by another type which spreads the solid stream by deflecting it. Spreaders are necessary for breaking up the solid stream when spraying shrubbery and the lower parts of tall trees.

Fig. 3.—An arsenate of lead mixer. When paste arsenate of lead is used, as a rule it is necessary to mechanically break it up. Various mixers are used, this being one of the churn type.

PLATE XIV





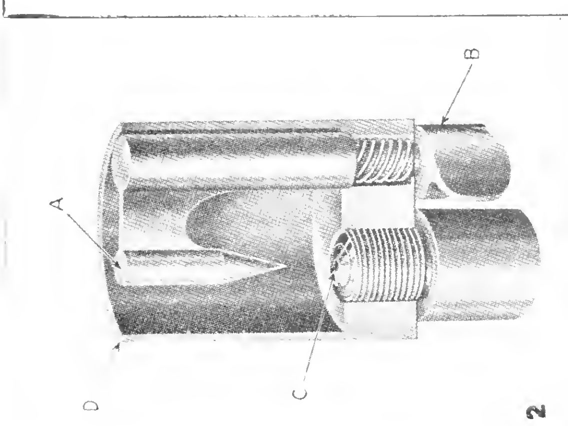


PLATE XV

THE MIST SPRAYER USED FOR SOLID STREAM WORK

Fig. 1.—A moderate capacity power sprayer of the mist type being used for solid stream work. Such machines are not satisfactory for this purpose. In this picture a spreader is in place breaking up the stream for spraying the lower part of the tree. Marietta, Ohio.

Fig. 2.—This picture shows the maximum height it was possible to reach with the machine described above. Marietta, Ohio.

PLATE XV

PLATE XVI

INEFFICIENCY AND EFFICIENCY IN SPRAYING

Figures 1 and 2 contrast the climbing method which is necessary when mist sprayers are used for the treatment of tall trees, and the solid stream method of spraying. With the solid stream method one is able to spray the trees on half of a city block, while one tree is being sprayed by the climbing method. Moreover, the trees treated by the solid stream method will be more thoroughly sprayed and at the same time the work is more enjoyable for the operators.

PLATE XVI

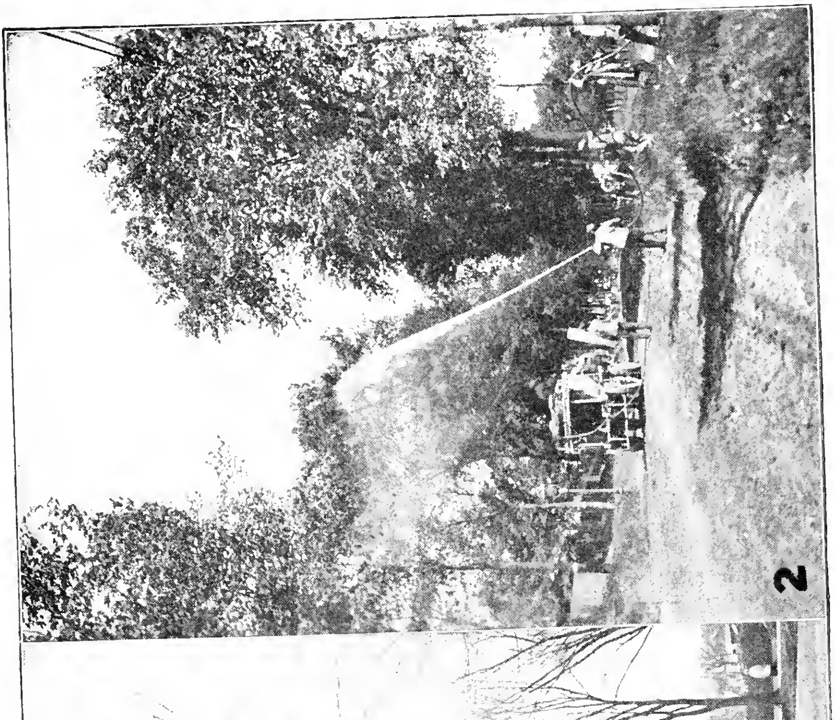


PLATE XVII

THE WHITE MARKED TUSSOCK MOTH

(*Hemerocampa leucostigma*)

Fig. 1.—A full-grown larva about twice natural size. This illustration shows very plainly the three pencils of long black hairs and the sparse black hairs intermingled with the white tufts on the sides of the body. Note also the insert in Fig. 2. The four white tussocks on the back which do not show so plainly in Fig. 1, are shown more plainly here.

Fig.2.—A cluster of cocoons in a cavity in the trunk of a small tree.

Fig. 3.—A large willow tree showing a profuse infestation of cocoons and egg-masses of the tussock moth.

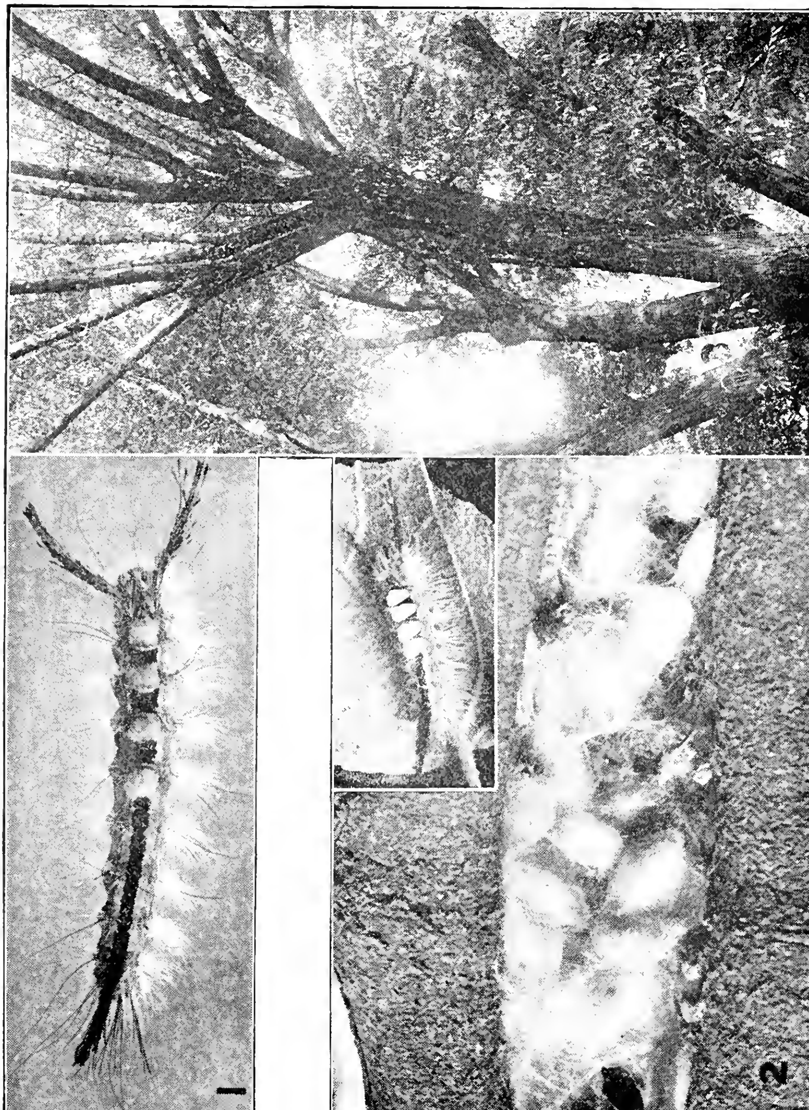


PLATE XVIII

THE WHITE MARKED TUSSOCK MOTH

(*Hemerocampa leucostigma*)

Fig. 1.—The frothy egg mass on the outside of the cocoon, about natural size.

Fig. 2.—Adult female of the tussock moth clinging to the cocoon from which she has emerged. Natural size.

Fig. 3.—Adult male, slightly smaller than natural size.

Fig. 4.—Elms, Cincinnati, Ohio, defoliated by tussock moth.

Fig. 5.—Horse chestnut, Cleveland, Ohio, defoliated by tussock moth.

Fig. 6.—Nymphs of a stink bug piercing the cocoon of the tussock moth and feeding on the pupa within.

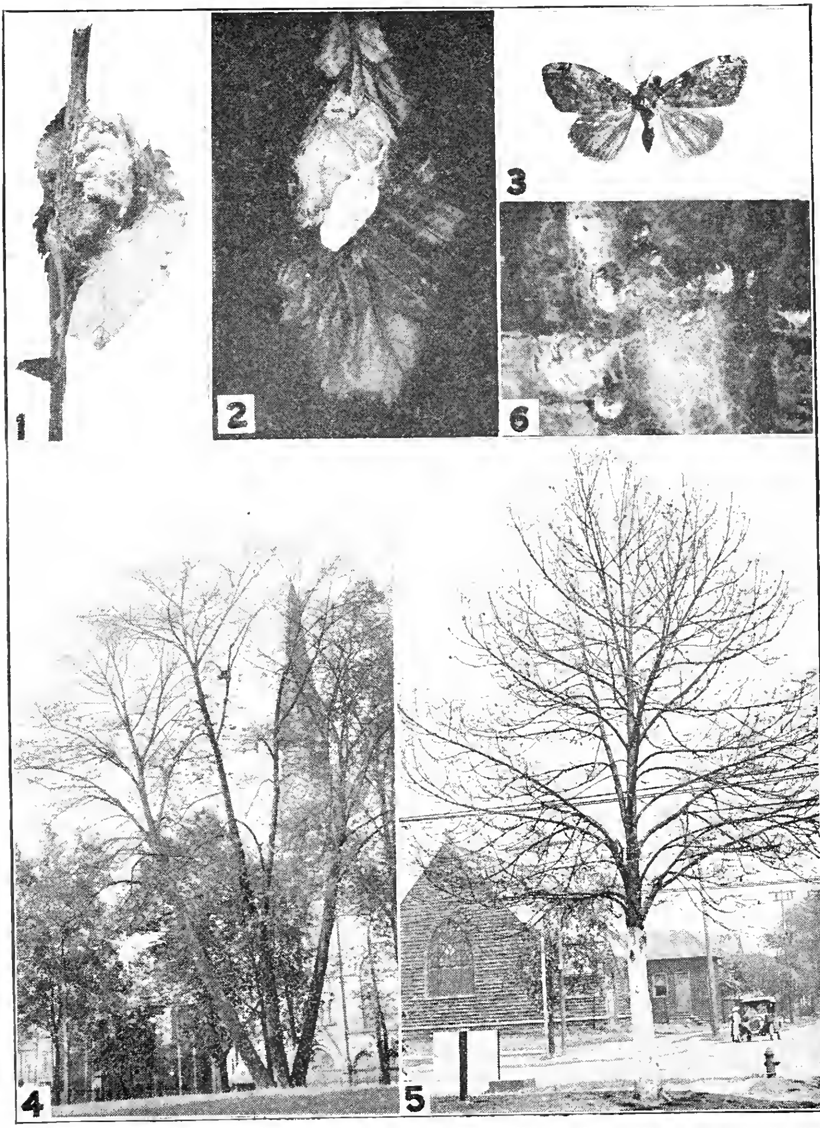


PLATE XIX

THE WHITE MARKED TUSSOCK MOTH

(*Hemerocampa leucostigma*)

Fig. 1.—Witch hazel, Rockfeller Park, Cleveland, Ohio, photographed July, 1914, after having been defoliated by the first brood of tussock moth larvae. About the time the caterpillars reached maturity they were attacked by an infectious bacterial disease and practically every one was killed by it. At the time the photograph was taken, the dead and shriveled caterpillars were lying thick upon the ground.

Fig. 2.—So perfect was the work of destruction by the caterpillar disease, the clump of witch hazel was able to develop a second crop of foliage which was practically unmolested by the insects. This photograph was taken just before frost.

PLATE XIX

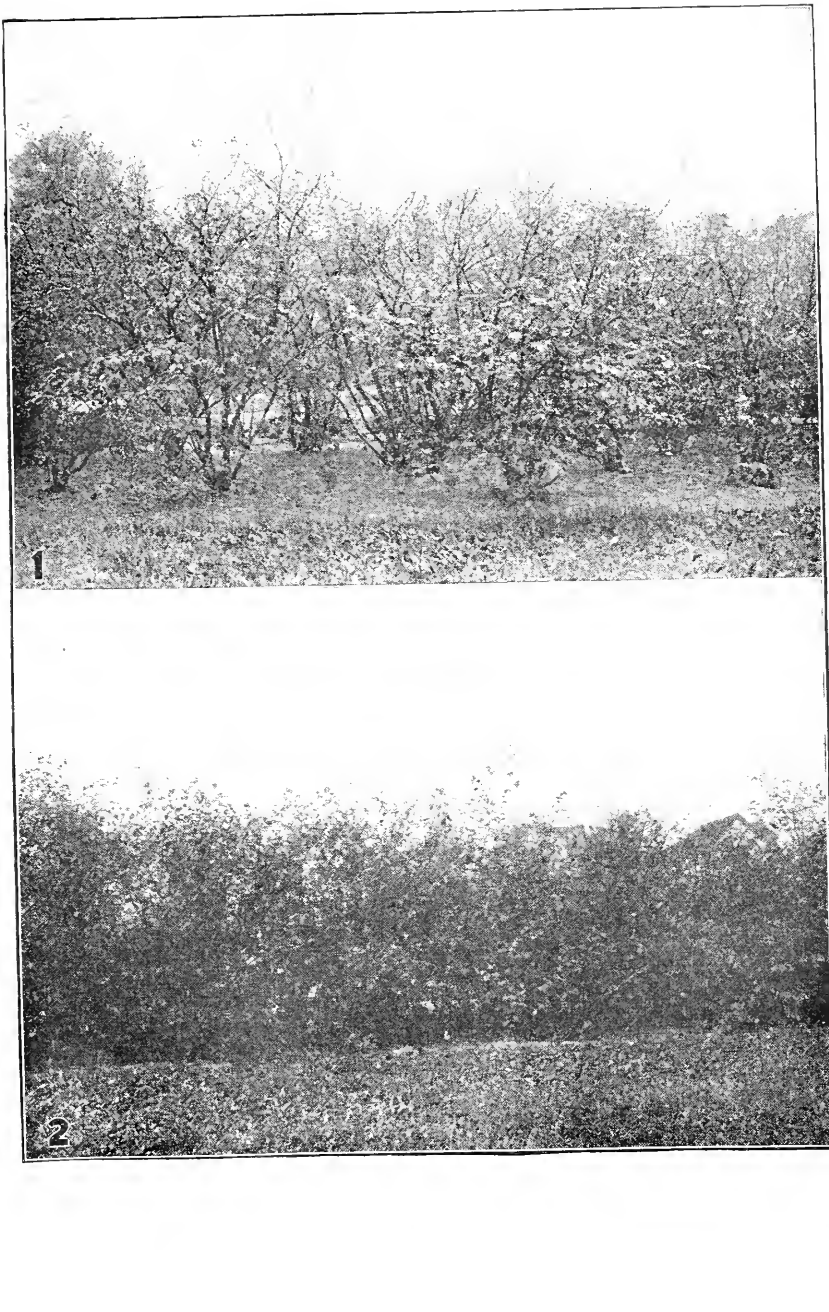


PLATE XX

THE FALL WEBWORM
(Hyphantria cunea)

Fig. 1.—Adult, larvae and pupae, all slightly enlarged. The three illustrations of the larva indicate the variability in coloring of the insect in this stage.

After Riley.

Fig. 2.—The silken web which encloses the cluster of feeding caterpillars.

Fig. 3.—A sycamore tree practically defoliated by the fall webworm. The discarded, unsightly webs may be seen still attached to the tree.

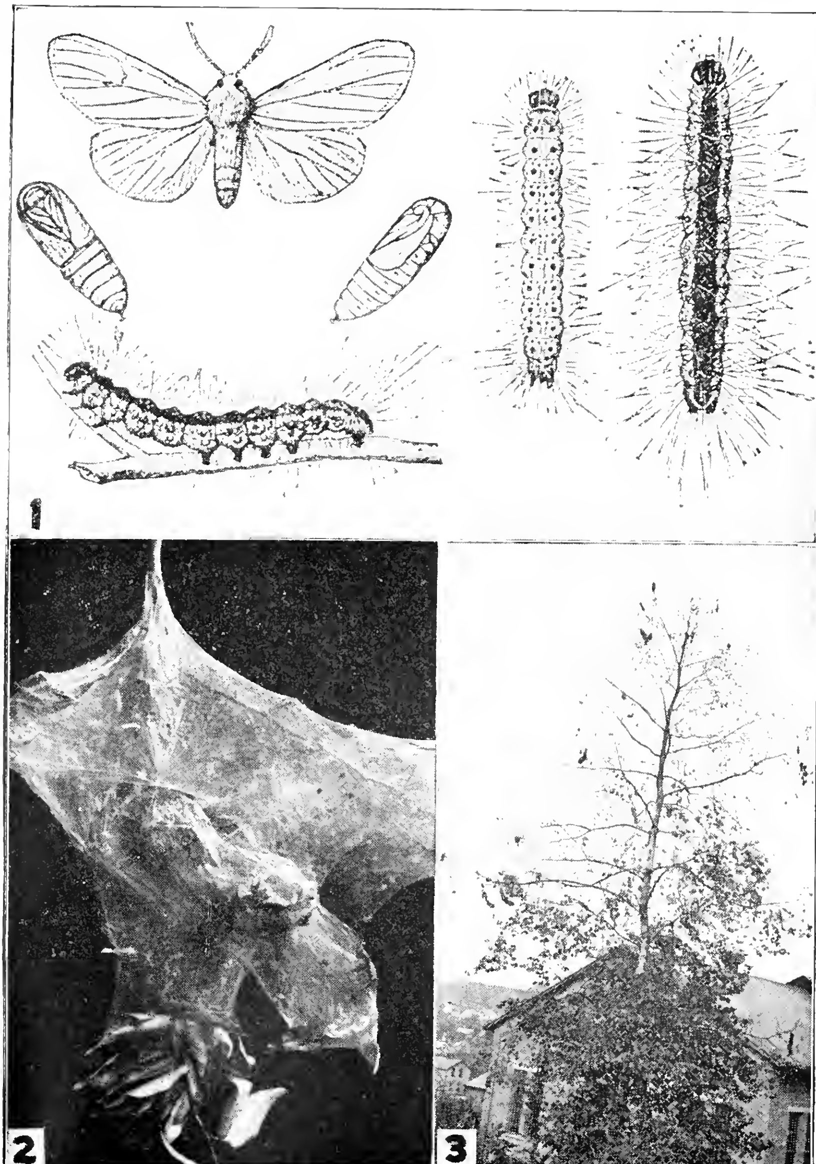

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PLATE XXI

THE BAG OR BASKET WORM
(Thyridopteryx ephemeraeformis)

Fig. 1.—Over-wintering bags attached to willow.

Fig. 2.—Over-wintering bags on arbor vitae.

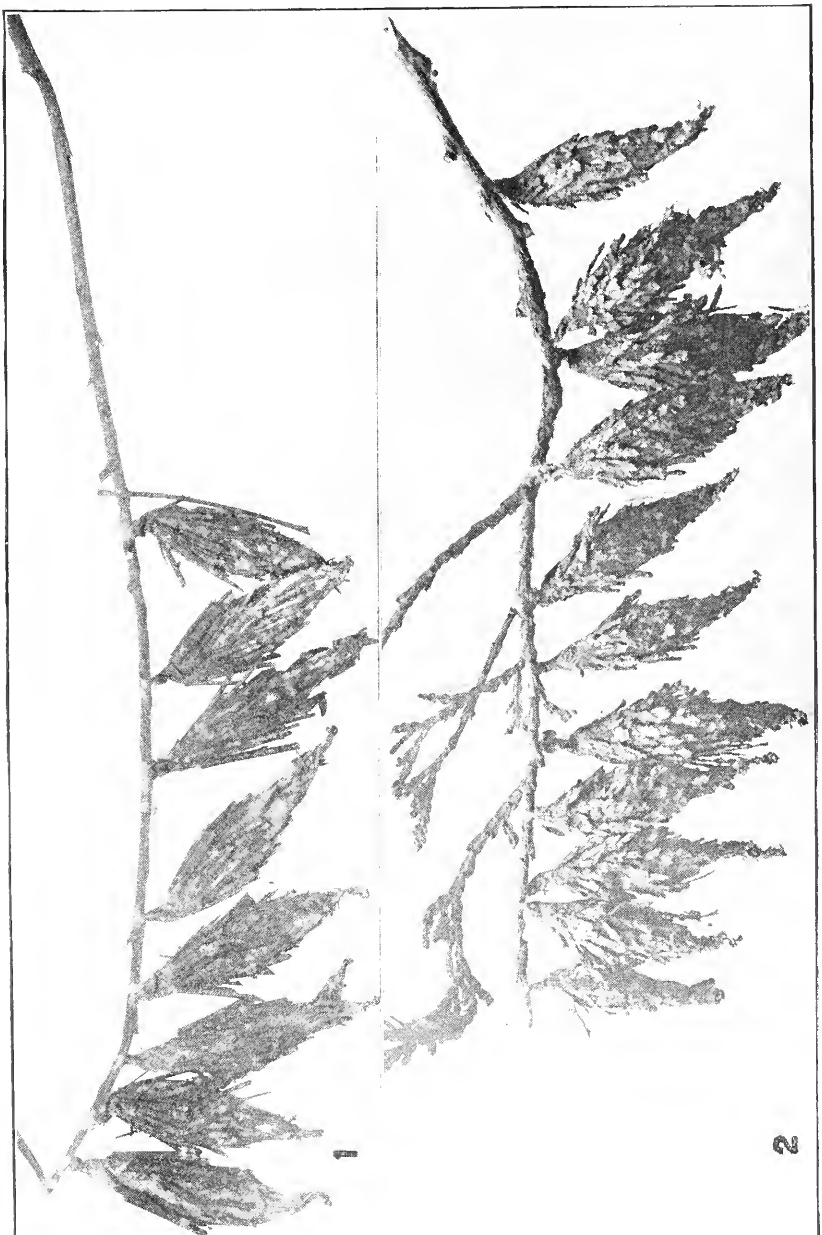

PLATE XXII

THE BAG OR BASKET WORM
(*Thyridopteryx ephemeraeformis*)

10. "Bag or larval case as seen in winter, natural size.

11. Same as preceding but cut open to show the pupal case and the eggs.

12. Several eggs, very greatly enlarged.

13. Side view of recently hatched larva, greatly enlarged.

14. Cases of young larvae on twig, natural size. Notice that the dark ones are on the dark bark and the light ones on the light bark.

14a. Leaf eaten by young larvae, natural size.

15. Older larvae in their bags which are ornamented with pieces of leaves, one is on the leaf, another hanging from the edge and a third dangling by a thread, natural size.

16. Full-grown larva removed from its case, natural size.

17. Full-grown larva walking with its case, natural size.

19. Wingless female moth, natural size.

20. Male moth with wings spread, natural size.

22. Bag of male hanging from the leaf and with the empty pupal case protruding from its lower extremity, natural size. The leaf in front of the bag shows the work of half grown larvae."

After Felt.

PLATE XXII

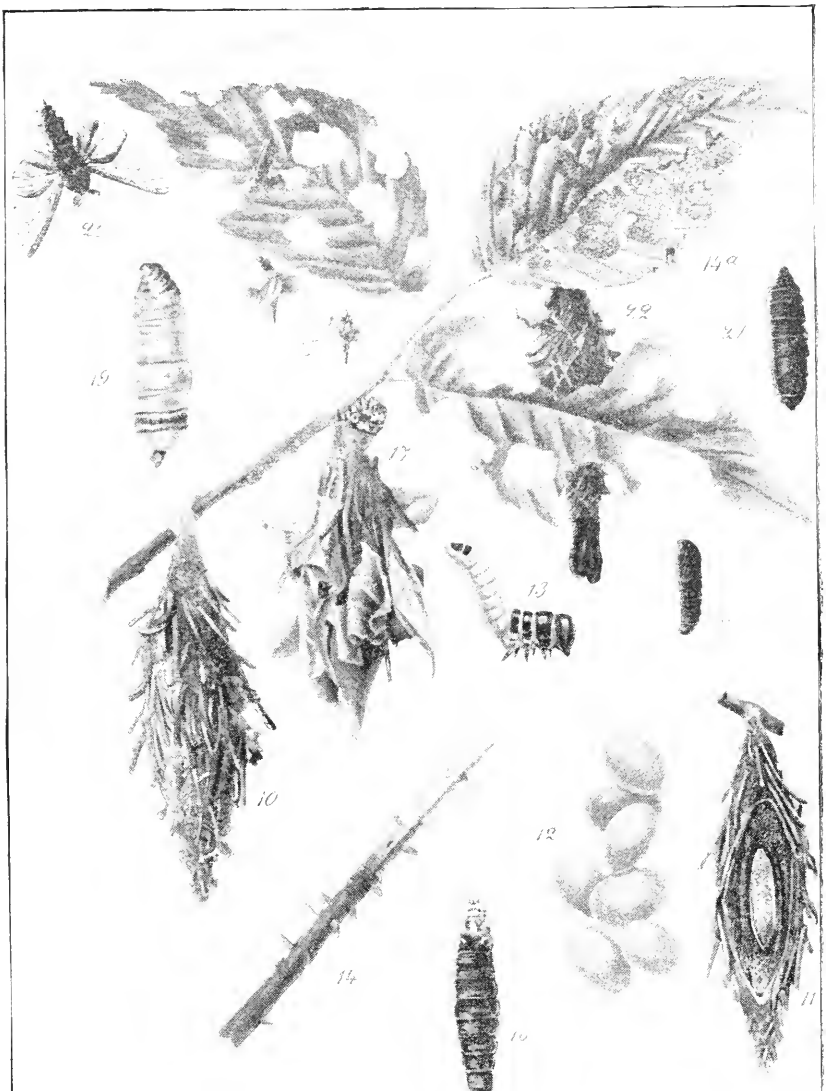

PLATE XXIII

THE BAG OR BASKET WORM
(*Thyridopteryx ephemeraeformis*)

Fig. 1.—Branch of hard maple badly mutilated by the feeding caterpillars.

Fig. 2.—A small hard maple tree, Cincinnati, Ohio, almost defoliated by the bag worm.

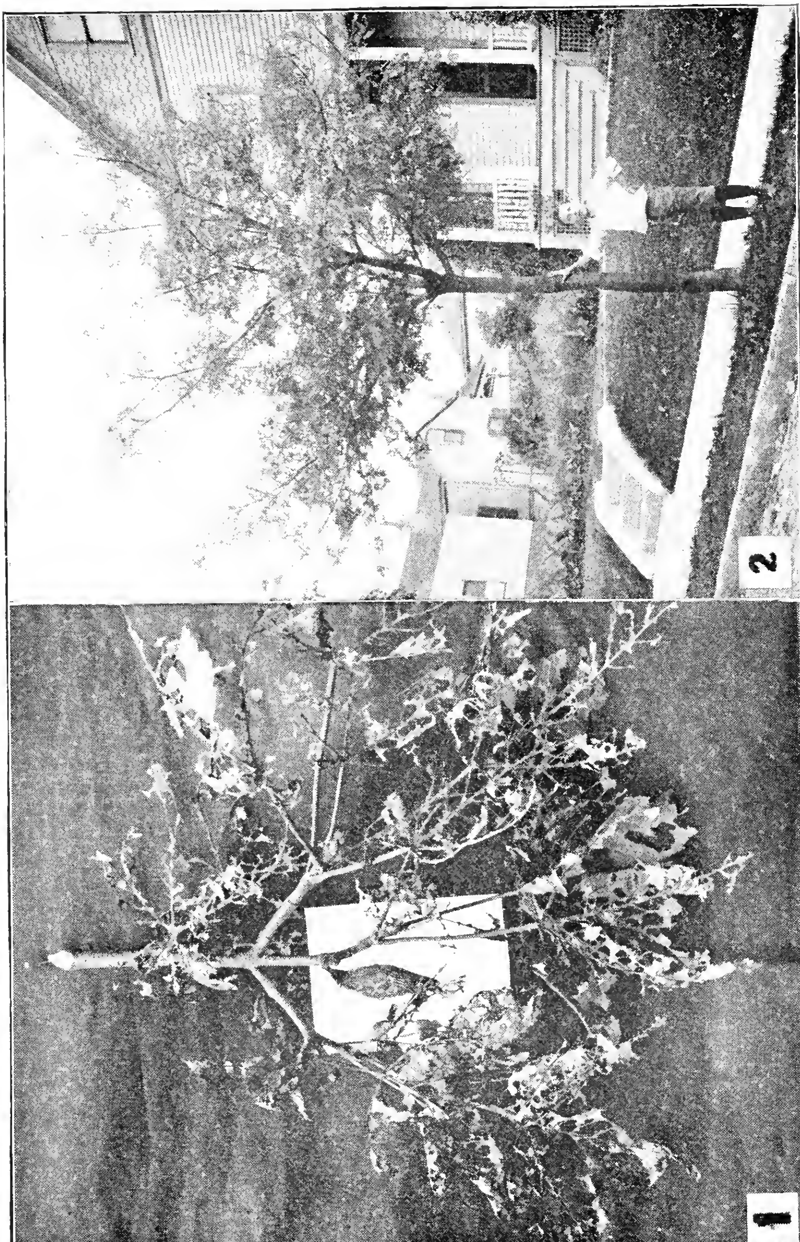
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PLATE XXIV

THE ELM LEAF BEETLE
(*Galerucella luteola*)

1. "Cluster of eggs much enlarged.

1a. Side view of single egg, still more enlarged.

2. Dorsal view of recently hatched larva or grub, much enlarged.

3. Dorsal view of full grown larva or grub, much enlarged.

4. Pupa, much enlarged.

5. Over-wintered beetle, much enlarged.

6. Fresh, brightly-colored beetle, much enlarged.

7. Under surface of leaf showing eating of larva or grubs and a few holes eaten by beetles, eggs in clusters, cast larval skins and full-grown larvae, natural size.

8. Leaf nearly skeletonized by grubs or larvae and on it three cast larval skins, natural size.

9. Leaf showing holes eaten by beetles, natural size."

After Felt.

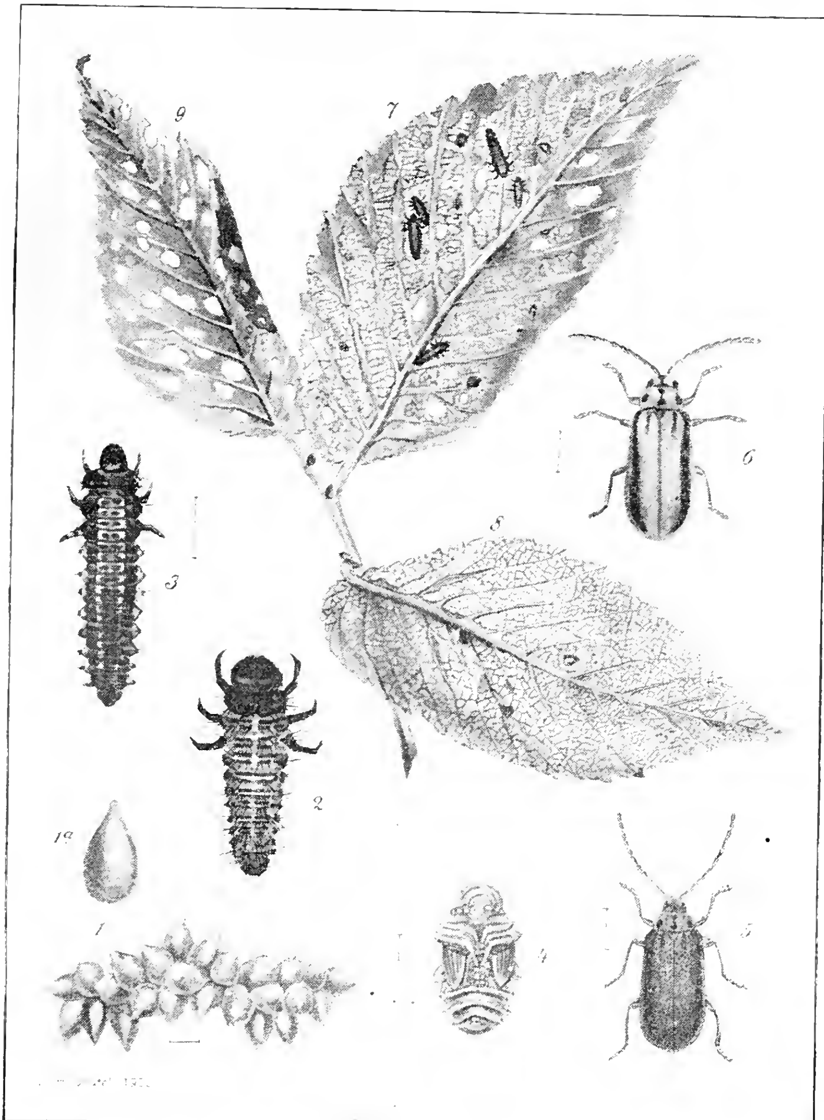
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PLATE XXV

THE ELM LEAF BEETLE
(*Galerucella luteola*)

Fig. 1.—Adult beetles killed by one of the stink bugs (*Apateticus maculiventris*).

.**Fig. 2.**—Elm leaf beetle, larvae, adults and pupae killed by a species of fungus disease (*Sporotrichum globuliferum*). The dead insects were in the refuse on the surface of the soil beneath an elm that had been severely attacked by the beetle. The white spots to which the black arrows point are the fungus-covered insects. Photograph, Dayton, Ohio.

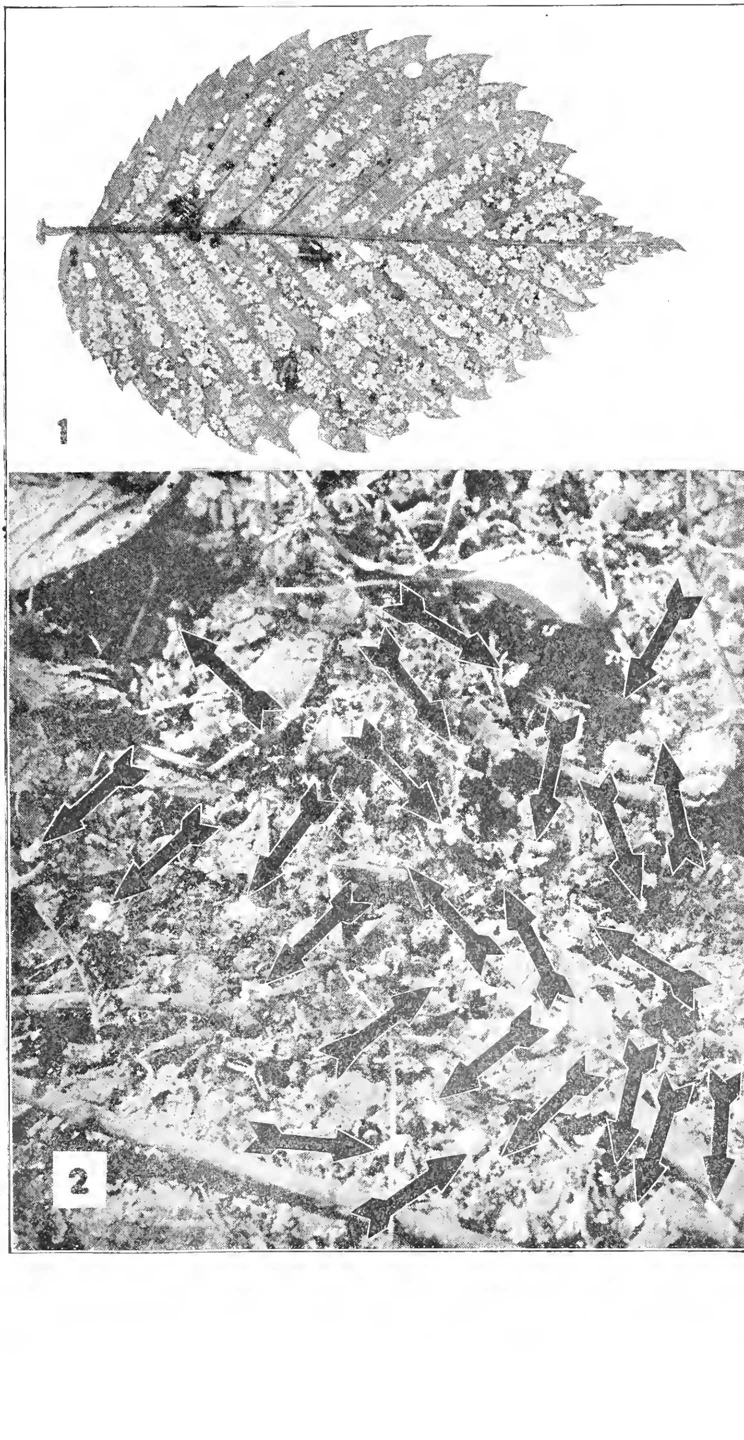
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PLATE XXVI

THE ELM LEAF BEETLE
(*Galerucella luteola*)

Fig. 1.—English elms, Dayton, Ohio, defoliated by the leaf beetle.

Fig. 2.—English elms, on the opposite side of the street from those of Fig. 1. These trees were protected by spraying at the proper time with arsenate of lead.

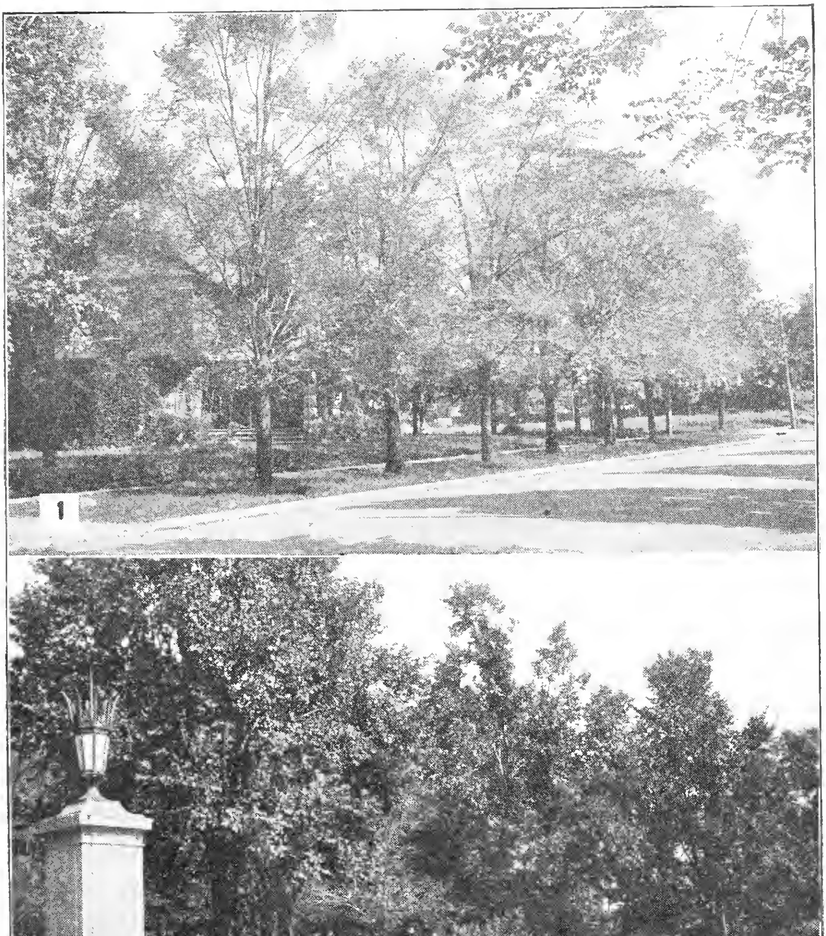

PLATE XXVII

THE FALL CANKER WORM
(*Alsophila pometaria*)

Fig. 1.—Adult moth. Enlarged about 2½ diameters.

Fig. 2.—Female wingless moth on egg cluster. Enlarged about 2½ diameters.

Photograph, W. H. Goodwin.

Fig. 3.—Egg mass, enlarged.

Photograph, W. H. Goodwin.

Fig. 4.—Cluster of feeding caterpillars.

Photograph, W. H. Goodwin.

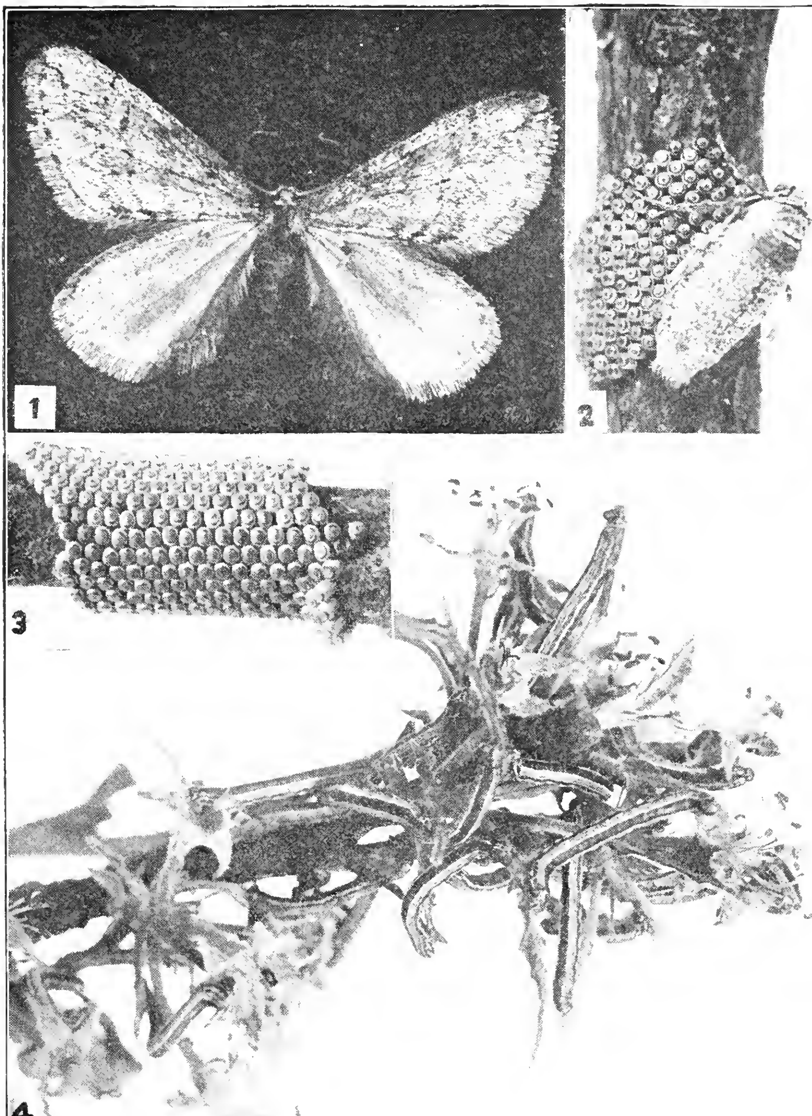
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PLATE XXVIII

CANKERWORMS
(*Alsophila pometaria*)
(*Paleacrita vernata*)

Fig. 1.—Male and female moths caught on a band of sticky tanglefoot.

Fig. 2.—Typical foliage injury by well grown cankerworm larvae.

Fig. 3.—A woodland near Cleveland, Ohio, practically defoliated by cankerworm larvae. Photograph, May 28, 1918.

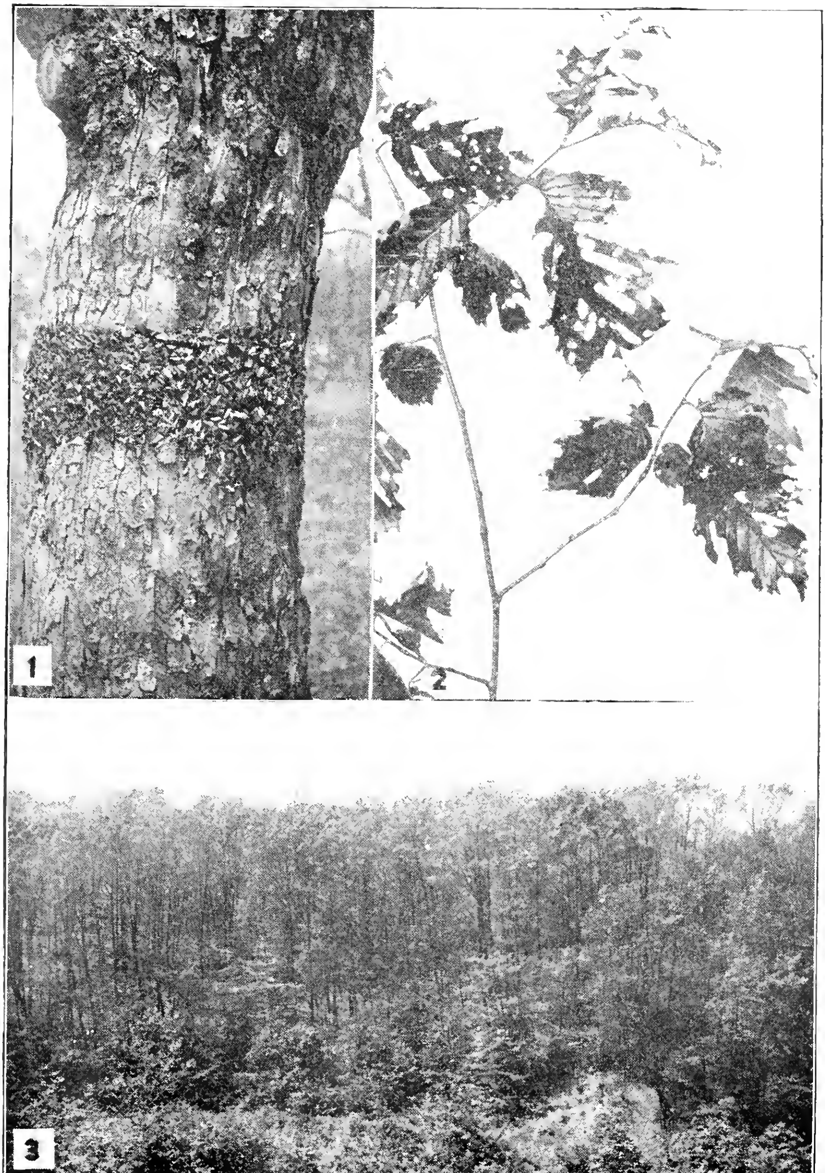
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PLATE XXIX

THE BLACK WALNUT DATANA

(*Datana integerrima*)

Fig. 1.—Adult female moth. Enlarged 1½ diameters.

Fig. 2.—Pupa slightly enlarged.

Fig. 3.—Egg mass, about natural size.

Photograph, J. L. King.

Fig. 4.—Cluster of molting caterpillars on the trunk of a walnut tree.

Fig. 5.—Cluster of feeding caterpillars, much smaller than natural size.

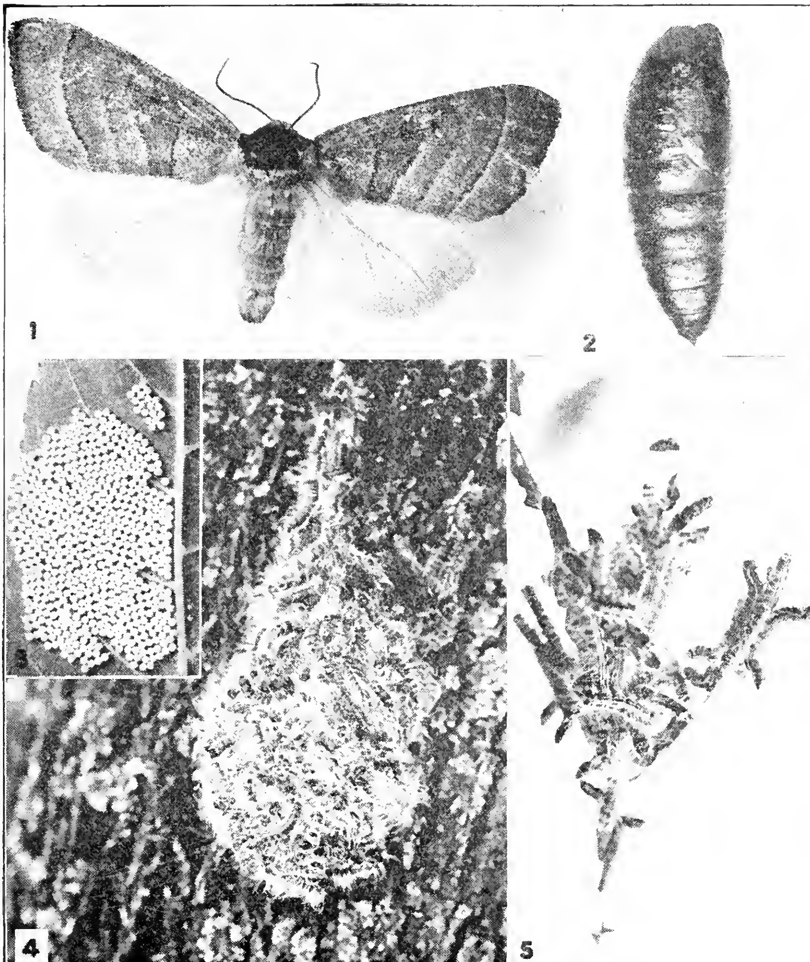
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PLATE XXX

THE BLACK WALNUT DATANA
(*Datana integerrima*)

A black walnut tree defoliated by this insect, Mahoning County, Ohio, 1917. This is a very frequent sight in Ohio, particularly where walnut trees are found growing apart from other trees.

PLATE XXXI

THE APPLE DATANA
(*Datana ministra*)

Fig. 1.—Adult female moth. Enlarged about 1½ diameters.

Fig. 2.—Pupa, enlarged.

Fig. 3.—Cluster of caterpillars feeding on apple. The characteristic attitude of the larva when disturbed is shown by some individuals in this group.


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PLATE XXXII

THE LOCUST LEAF BEETLE
(*Chalepus dorsalis*)

Fig. 1.—The adult beetle enlarged about 8 diameters.
After Garman.

Fig. 2.—The full grown larva enlarged about 7 diameters.
After Chittenden.

Fig. 3.—The pupa enlarged about 7 diameters.
After Chittenden.

Fig. 4.—A leaf of black or yellow locust bearing several mines of the locust leaf beetle. As shown by the illustration each leaflet ordinarily bears but one mine.

Fig. 5.—A typical view of the black locust areas of southern Ohio following several seasons of injury by this insect. The dead trees are black locust and the others are largely of other species, though a few locusts survived.

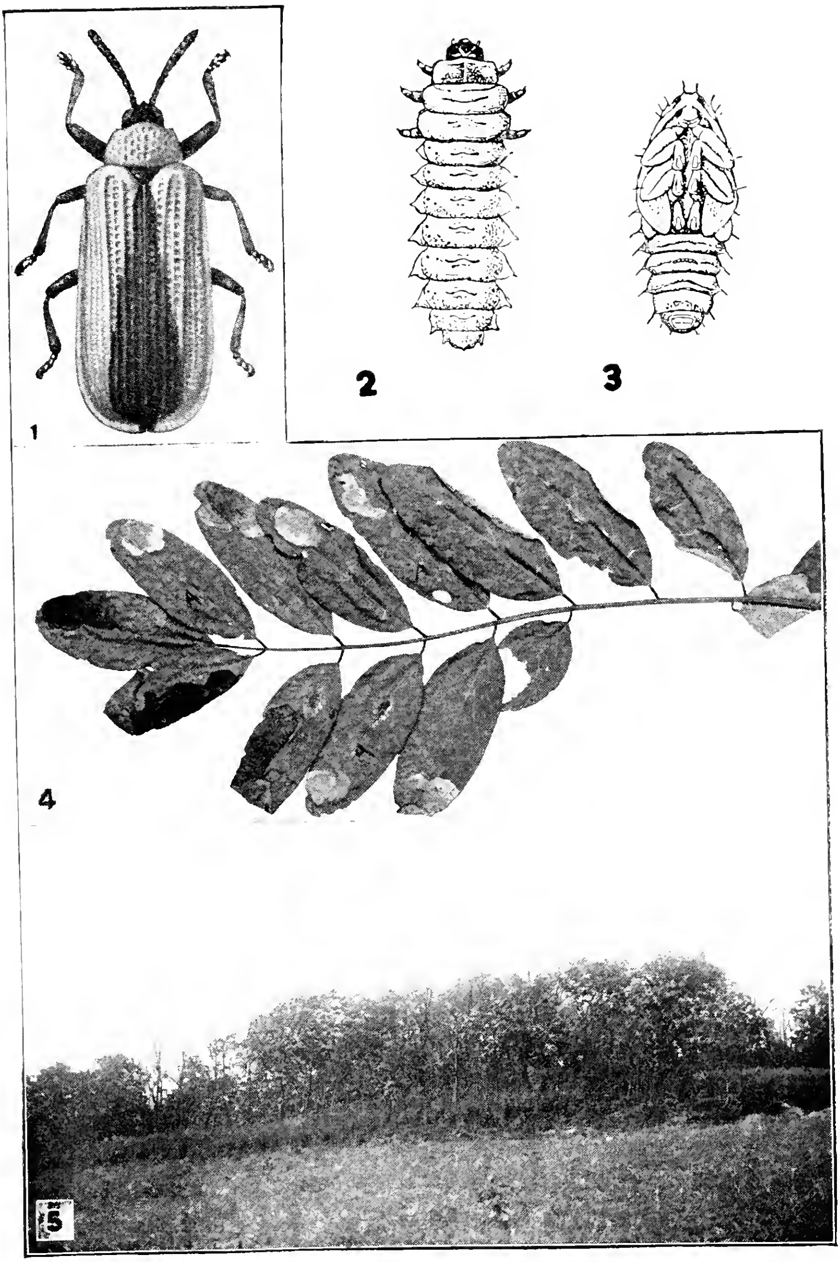

PLATE XXXIII

THE WHITE GRUB OR MAY BEETLE
(*Lachnosterna* sp.)

Fig. 1.—Adult beetles, slightly enlarged.

Fig. 2.—Full grown larva, slightly enlarged.

Fig. 3.—A young ash grove defoliated by May beetles, Wooster, Ohio, May, 1914. Ordinarily the damage is not so severe as shown in this illustration.
Photograph, W. H. Goodwin.

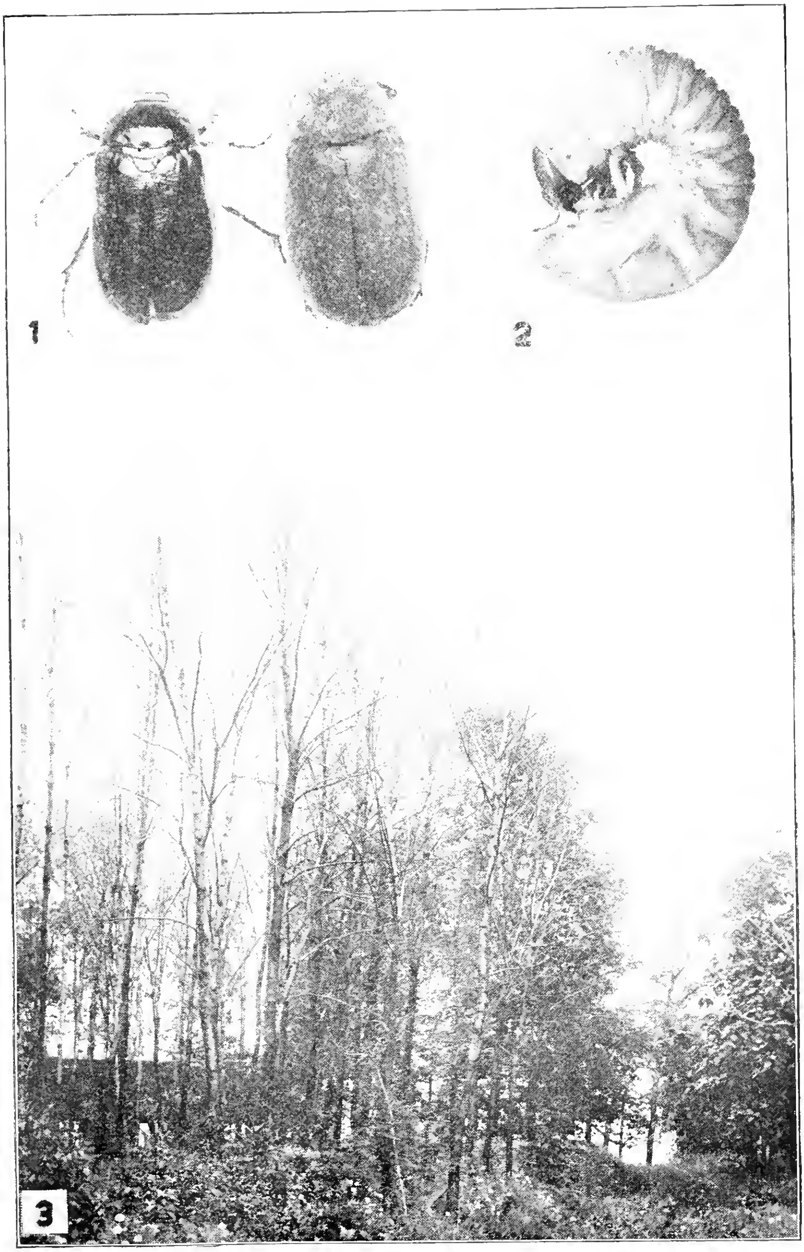
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PLATE XXXIV

THE CATALPA SPHINX
(Ceratomia catalpae)

a. Egg mass on underside of leaf.

b. Newly hatched larvae feeding upon epidermis of leaf.

c. A larva about one-third grown.

e, f, h. Larvae showing the different types of marking.

j. Pupa.

k. Moth, slightly less than natural size.

l. Egg, much enlarged.

After Riley.

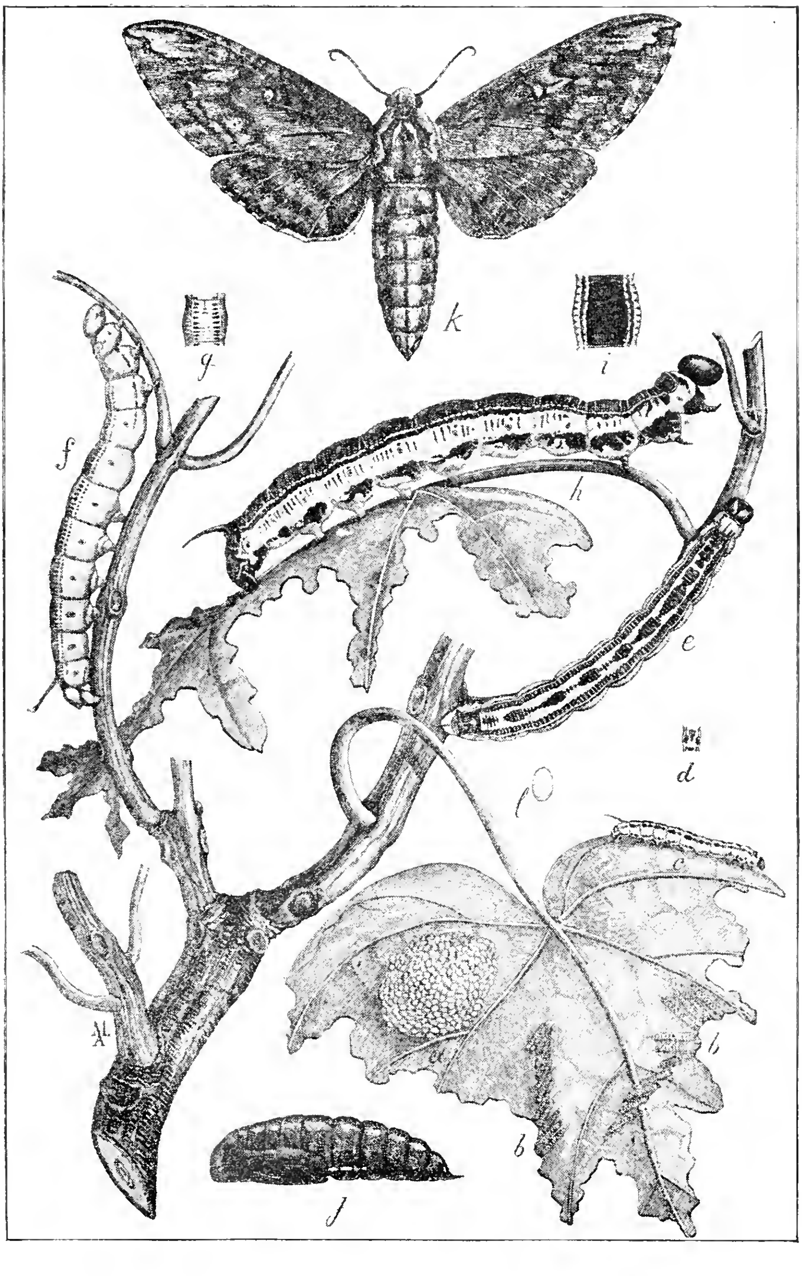
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PLATE XXXV

Fig. 1.—Work of the catalpa sphinx, showing complete defoliation. Occasionally entire plantations are defoliated.

Fig. 2.—The Forest Tent-Caterpillar (*Malacosoma disstria*). A cluster of larvae upon the trunk of a tree.

Photograph furnished by Prof. P. J. Parrott.

PLATE XXXV

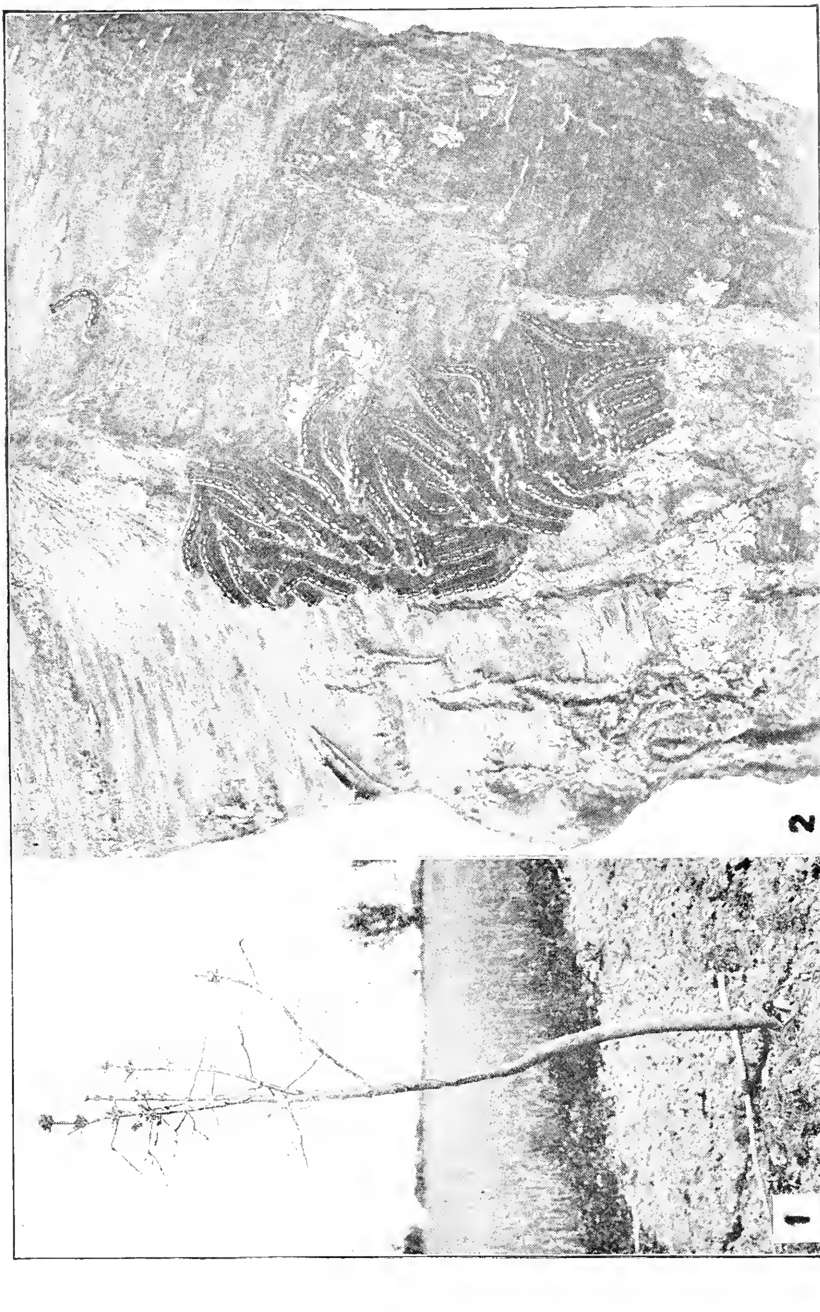


PLATE XXXVI

Fig. 1.—The Oak Tussock Caterpillar (*Halisidota maculata*). A larva enlarged about 3 diameters.

Fig. 2.—The Pale Tussock Caterpillar (*Halisidota tessellaris*). A larva enlarged about 3 diameters.

Fig. 3.—The Hickory Tussock Moth (*Halisidota caryae*). A larva natural size.

Photograph, Dr. W. E. Britton

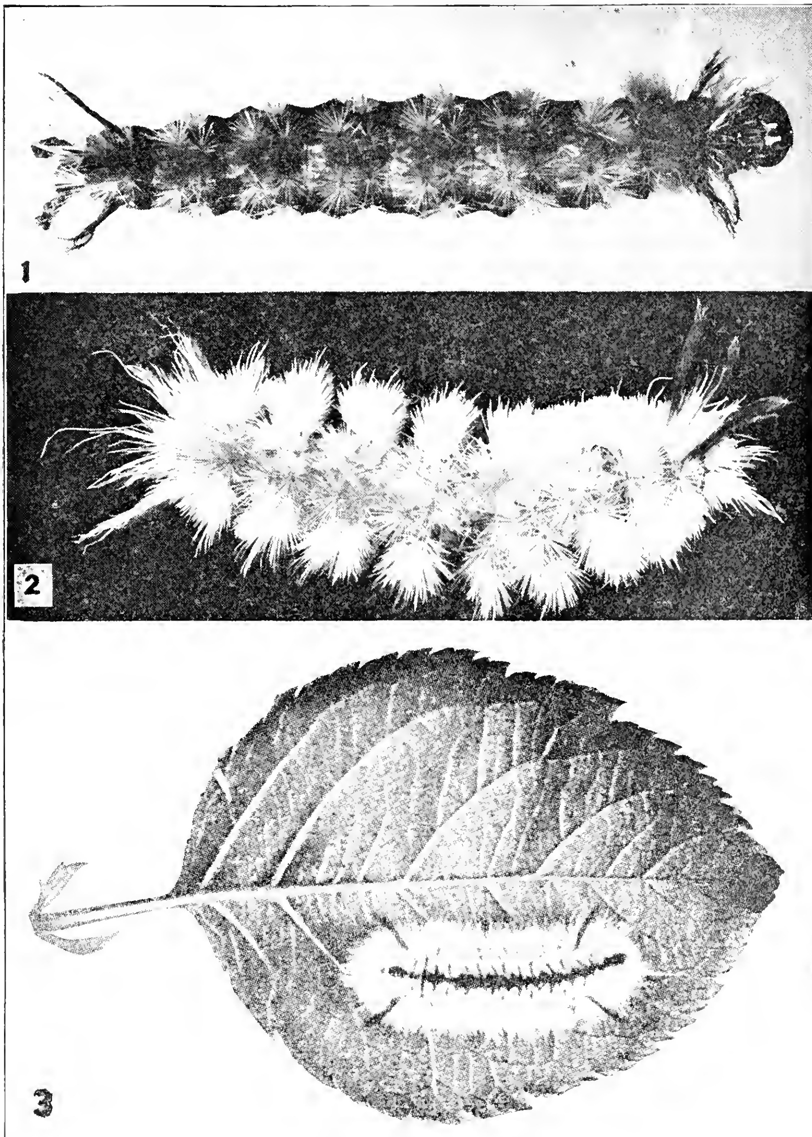


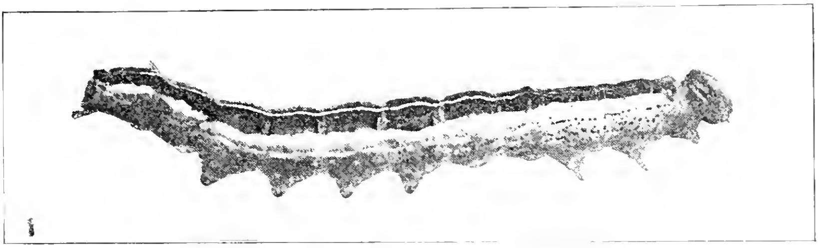
PLATE XXXVII

Fig. 1.—The Variable Oak Leaf Caterpillar (*Heterocampa manteo*). Full-grown larva enlarged about 3 diameters. As the name indicates, this caterpillar is quite variable in appearance, the most variable feature being the dark line extending down the back. In some specimens this is almost wanting.

Fig. 2.—The Yellow Striped Oak Caterpillar (*Anisota senatoria*). Full-grown caterpillar enlarged 2 diameters.

Fig. 3.—The Brown Anisota (*Anisota virginiensis*). Full-grown caterpillar enlarged about 2 diameters.

Fig. 4.—The Green-Striped Maple Worm (*Anisota rubicunda*). Full-grown caterpillar enlarged a little more than 2 diameters.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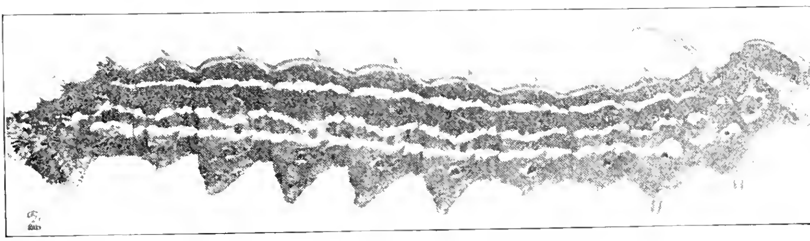

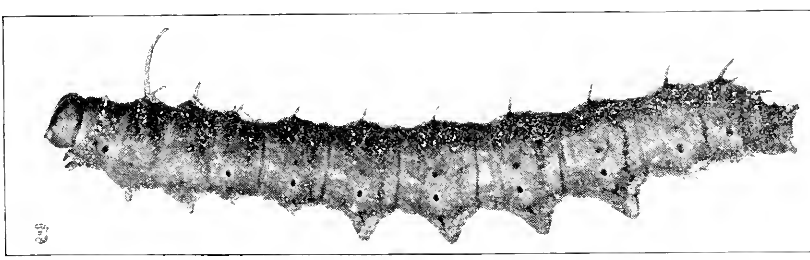

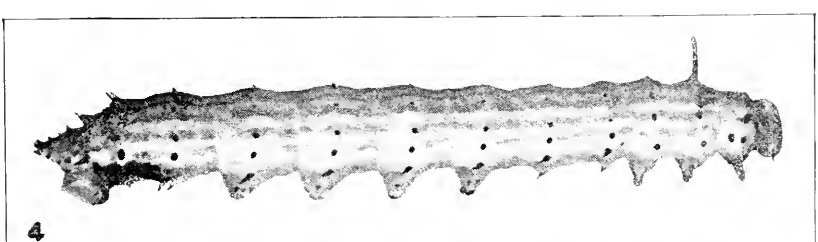
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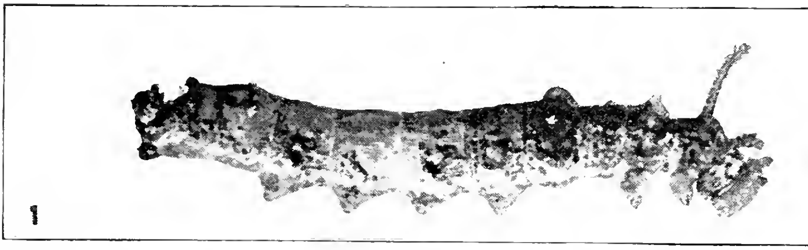
PLATE XXXVIII

Fig. 1.—The Viceroy (*Basilarchia dissippus*). A full-grown larva enlarged a little more than 2 diameters.

Fig. 2.—The Red-Humped Oak Worm (*Symmerista albifrons*). A full-grown caterpillar slightly enlarged.

Fig. 3.—The Red-Humped Apple Worm (*Schizura concinna*). A fully developed larva about twice natural size.

Fig. 4.—The Poplar Leaf-Tyer (*Melalopha inclusa*). A full-grown larva a little more than twice natural size.



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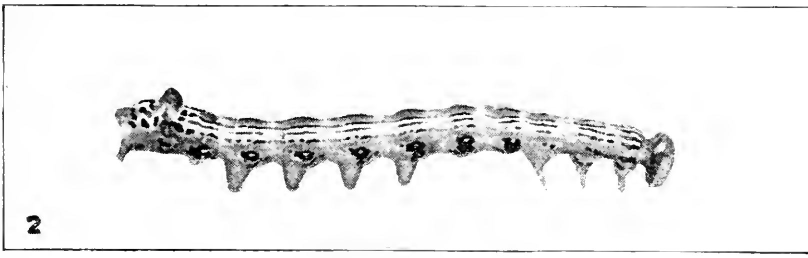

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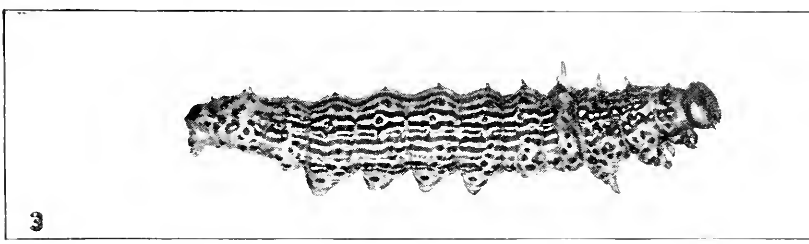

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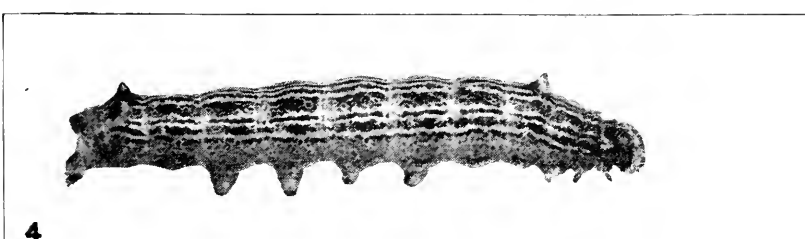

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PLATE XXXIX

Fig. 1.—Leafy retreats of the larvae of the poplar leaf tyer. These retreats are very easily mistaken for those of the brown tail moth.

Fig. 2.—The larvae of Abbott's pine sawfly (*Lophyrus abbotti*), about natural size.

Fig. 3.—A small tree of the short leaf pine at Fleming, Ohio, defoliated by the larvae of Abbott's pine sawfly.

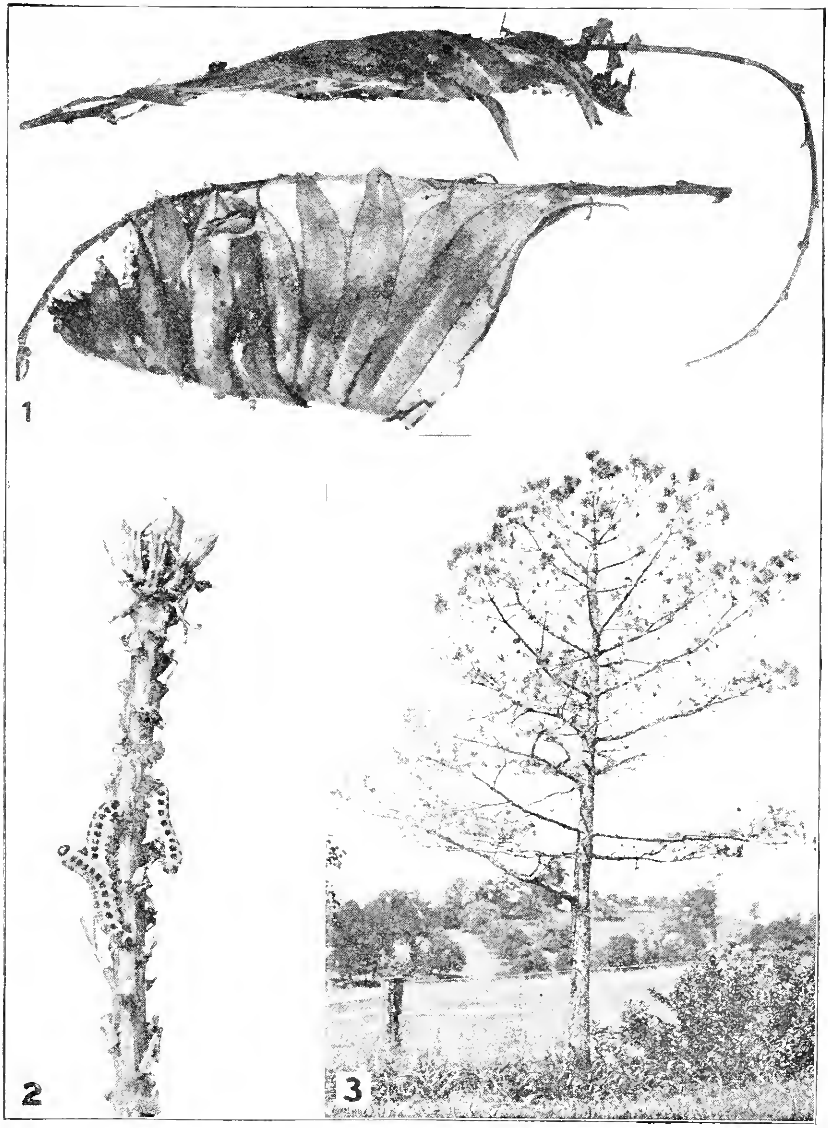
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PLATE XL

WILLOW AND COTTONWOOD LEAF BEETLES

Fig. 1.—The Spotted Willow Leaf Beetle (*Lina interrupta*). Three beetles showing the extreme variability of the markings.

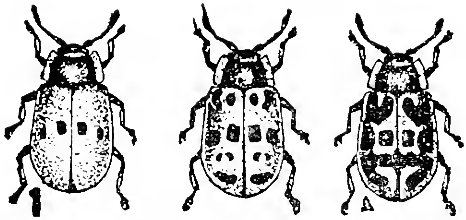
After Riley.

Fig. 2.—The Cottonwood Leaf Beetle (*Lina scripta*). Like the preceding, this beetle varies greatly in its markings, ranging from almost pure gold to almost black.

After Riley.

Fig. 3.—Clusters of pupae of the spotted willow leaf beetle attached to the mutilated leaves of willow.

Fig. 4.—Willows almost completely defoliated by the spotted willow leaf beetle at Wooster, Ohio.



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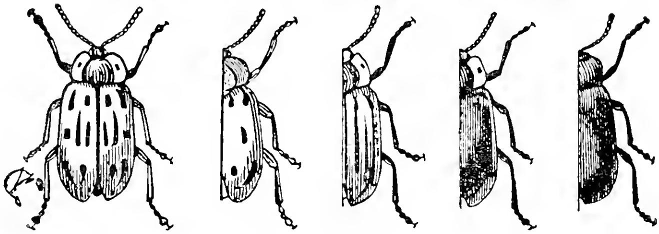

PLATE XLI

Fig. 1.—The Hickory Horned Devil or Regal Walnut Caterpillar (*Citheronia regalis*). Larva about four-fifths of natural size.

After Packard.

Fig. 2.—The Imperial Moth (*Basilona imperialis*). Caterpillar about natural size.

After Felt.

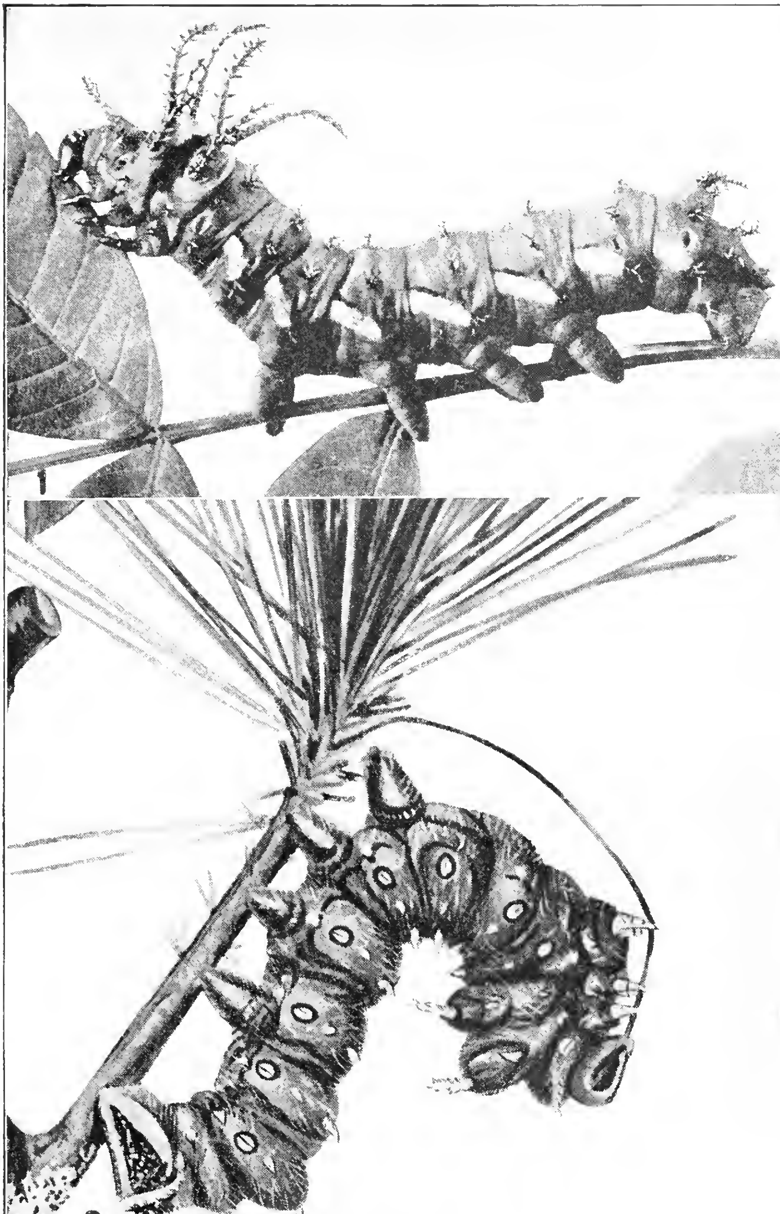
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PLATE XLII

Fig. 1.—The Cecropia Moth (*Samia cecropia*). Larva about three-fourths natural size.

After Riley.

Fig. 2.—The Luna Moth (*Tropea luna*). Larva a little over one-half natural size.

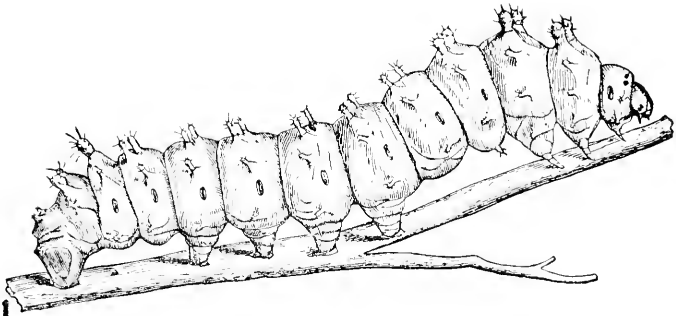
After Riley.

Fig. 3.—The Promethia Moth (*Callosamia promethia*). Larva about natural size.

After Riley.

Fig. 4.—The Polyphemus Moth (*Telea polyphemus*). Larva about three-fourths natural size.

After Riley.



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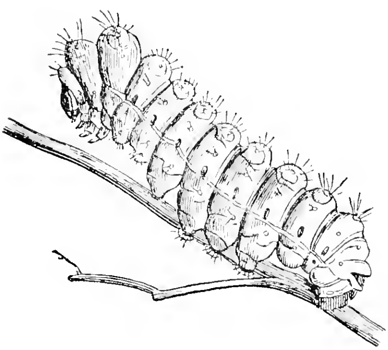

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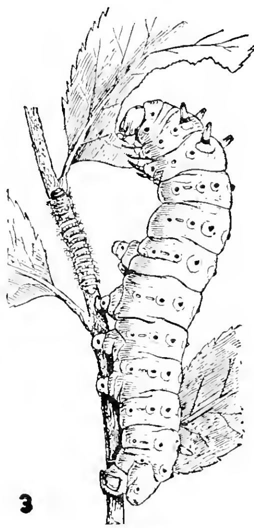

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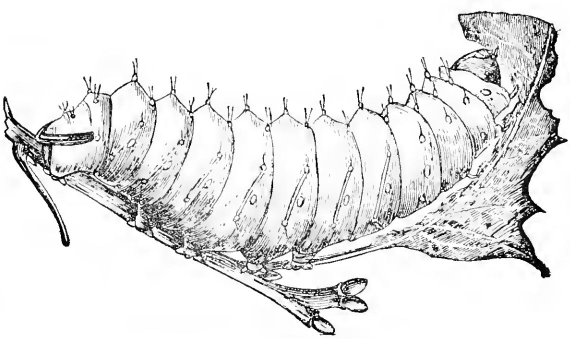

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PLATE XLIII

Fig. 1.—The Mourning Cloak Butterfly (*Euvanessa antiopa*). Cluster of caterpillars about one-half natural size.

Fig. 2.—The Io Moth (*Automeris io*). Adult female moth sligntly enlarged.

PLATE XLIII

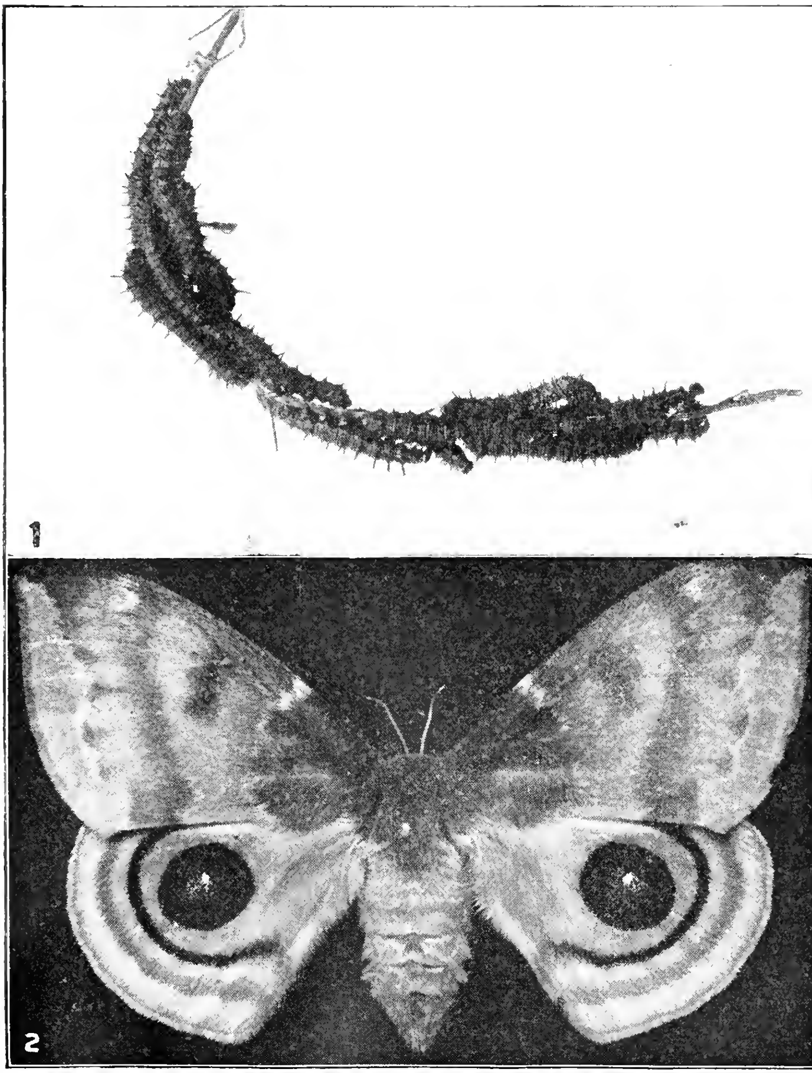


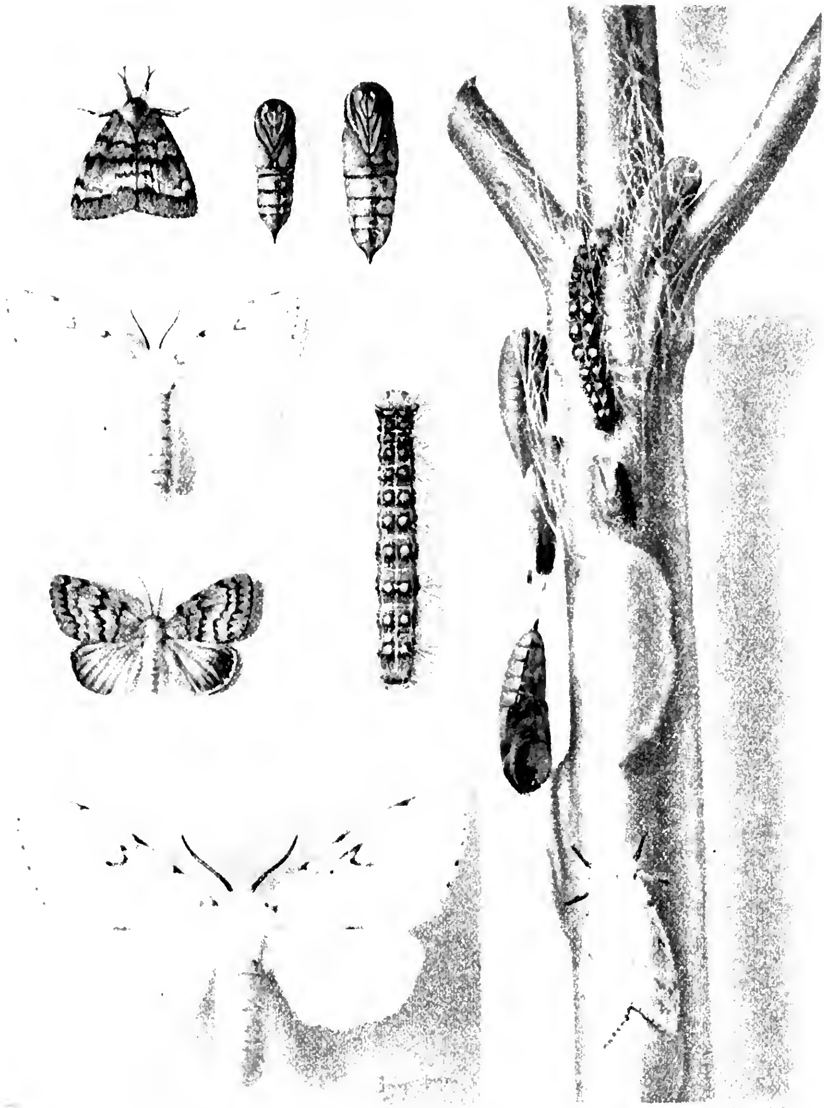
PLATE XLIV

THE GIPSY MOTH
(*Porthetria dispar.*)

"Egg mass on center of twig; female moth ovipositing just below; female moth below, at left, enlarged; male moth, somewhat reduced; female moth immediately above, somewhat reduced; male moth with wings folded in upper left; male chrysalis at right of this; female chrysalis again at right; larva at center."

After Howard & Fiske.

PLATE XLIV



A Hoen & Co Baltimore

From Bul. 91 Bureau of Entomology, U. S. Dept. of Agriculture.

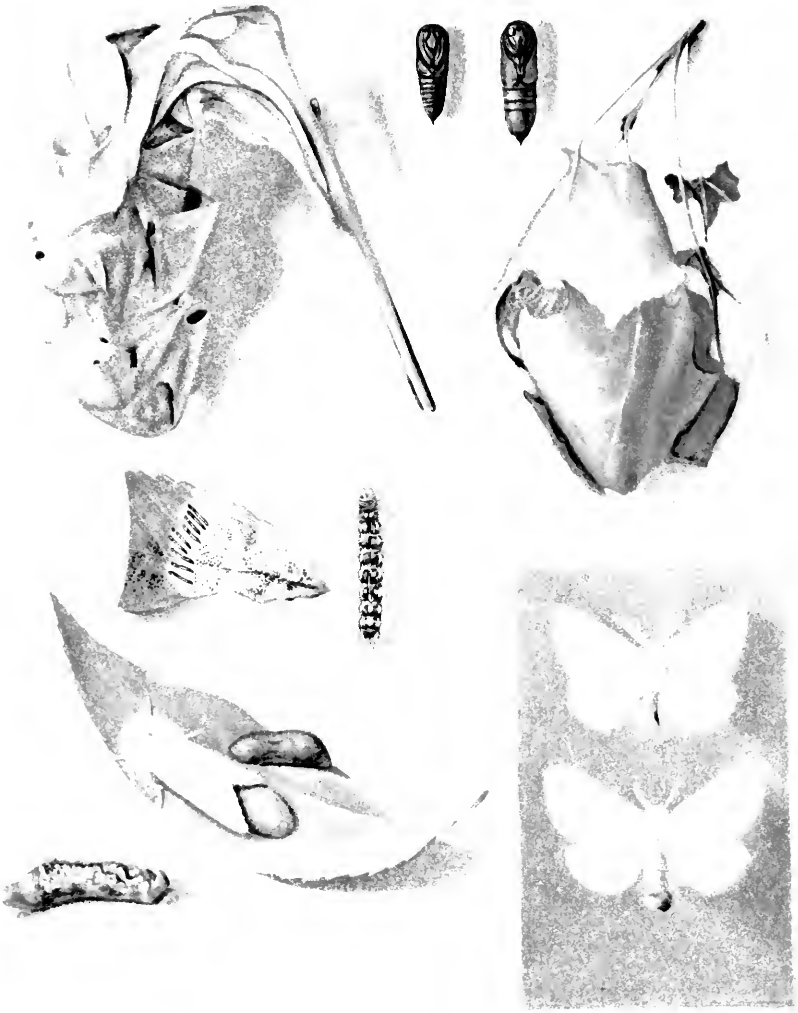
PLATE XLV

THE BROWN TAIL MOTH

(*Euproctis chrysorrhoea*)

"Winter nest at upper left; male and female adults, lower right; cocoon in leaf, upper right; male and female chrysalides above, male at left; full-grown larva in center; young larvae at its left; egg mass torn open showing eggs, at lower left; female ovipositing on leaf; egg mass on same leaf. All somewhat reduced."

After Howard & Fiske.



A Hoen & Co Baltimore

From Bul. 91, Bureau of Entomology, U. S. Dept. of Agriculture.

PLATE XLVI

Fig. 1.—New England coniferous woodland almost killed by gipsy moth larvae.

Fig. 2.—Deciduous woodland in New England ruined by the combined activities of gipsy and brown tail moth larvae.

PLATE XLVI

PLATE XLVII

Fig. 1.—The San Jose Scale (*Aspidiotus perniciosus*). Adult female scales enlarged.

Fig. 2.—The Putnam Scale (*Aspidiotus ancylus*). Young and adult scales enlarged.

Fig. 3.—The English Walnut Scale (*Aspidiotus juglans-regiae*). Young and adult scales enlarged. Note the clustering habit of this species.

Fig. 4.—The Obscure Scale (*Chrysomphalus obscurus.*) Young and adult scales enlarged. Note the shiny black nipples of the three scales in the center of the photograph. This glossiness is not apparent until the scales are rubbed and is then quite characteristic of the species.

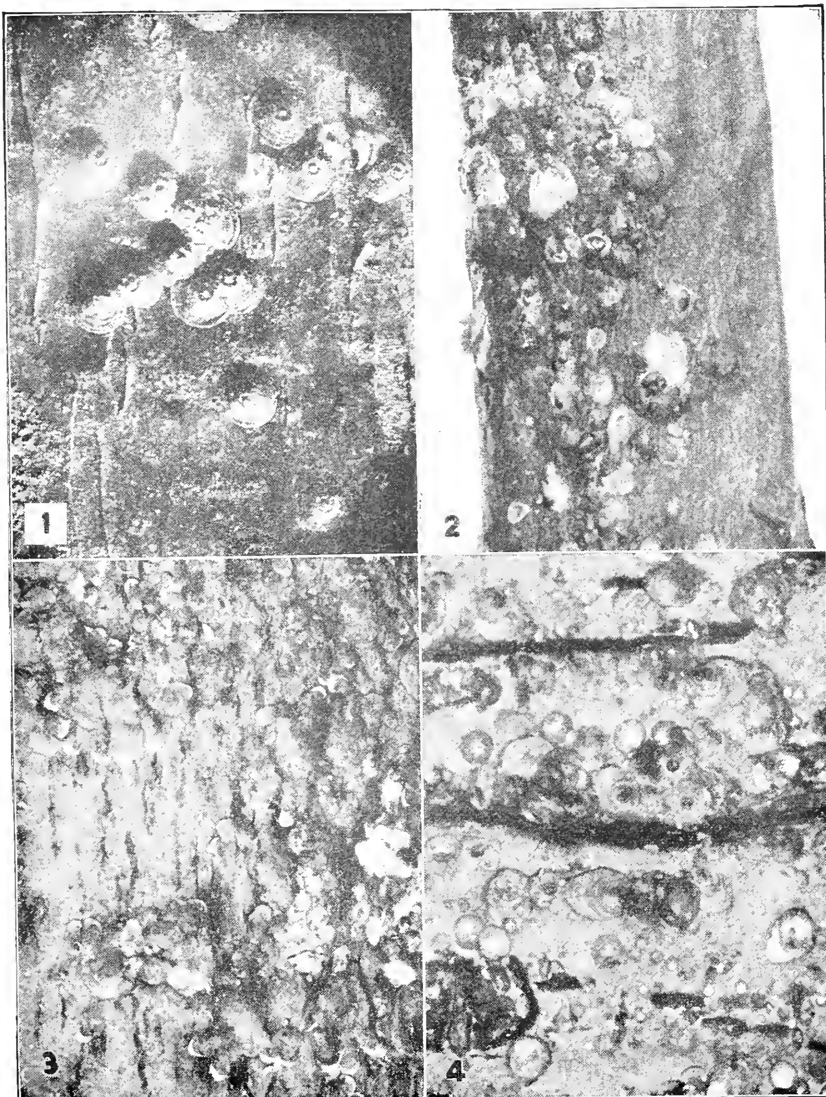

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PLATE XLVIII

Fig. 1.—The Oyster Shell Bark Louse (*Lepidosaphes ulmi*). Mature female scales, enlarged.

Fig. 2.—The Willow Scurfy Scale (*Chionaspis salicis-nigrac*). Mature female scales, enlarged.

Fig. 3.—The Scurfy Bark Louse (*Chionaspis furfura*). Male scales on twig at left, female scales on twig at right. Enlarged.

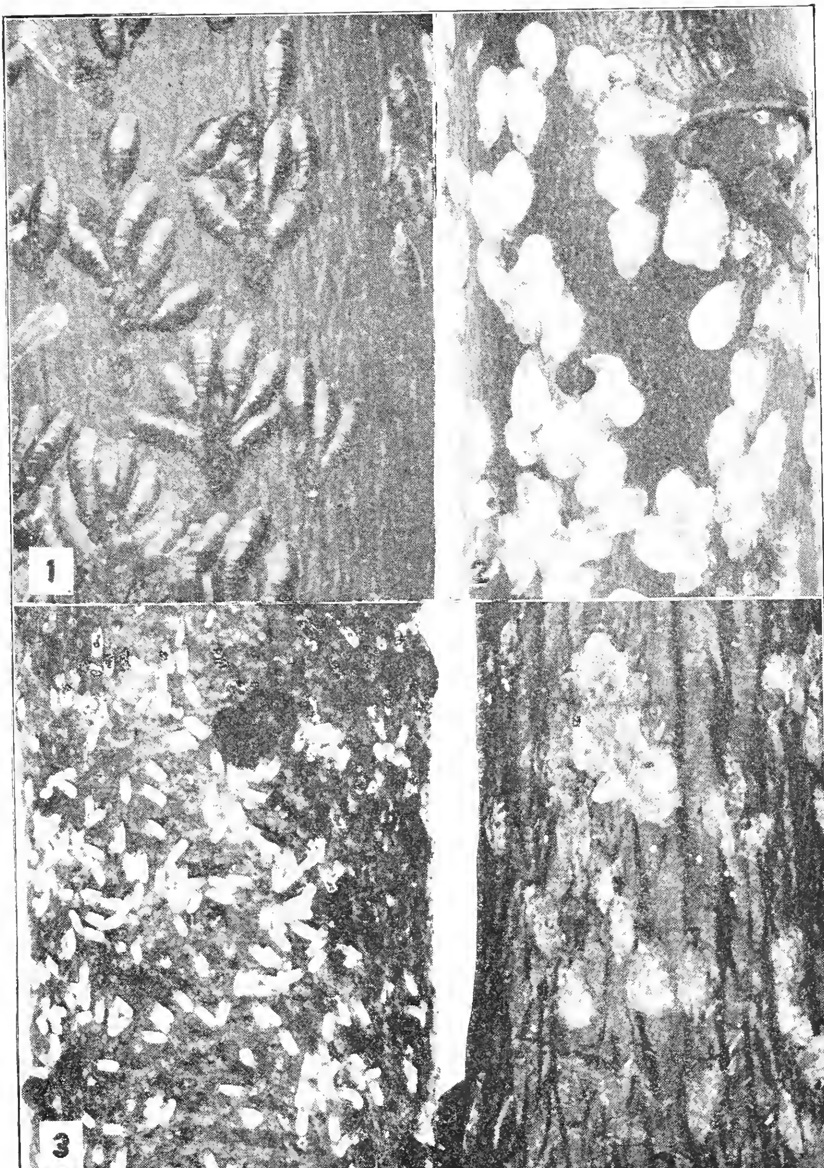

PLATE XLIX

Fig. 1.—The Pine Leaf Scale (*Chionaspis pinifoliae*). Mainly mature female scales, but on the upper needle are six smaller scales which are the mature male scales. Note the difference in the width of the female scales, those on the slender needle being very slender, while those on the broader needles are much broader. All much enlarged.

Fig. 2.—The Dogwood Scurfy Scale (*Chionaspis corni*). Mainly mature female scales. Enlarged.

Fig. 3.—The Elm Scurfy Scale (*Chionaspis americana*). Adult female scales, enlarged. Note the resemblance of this species to the oyster shell bark louse.

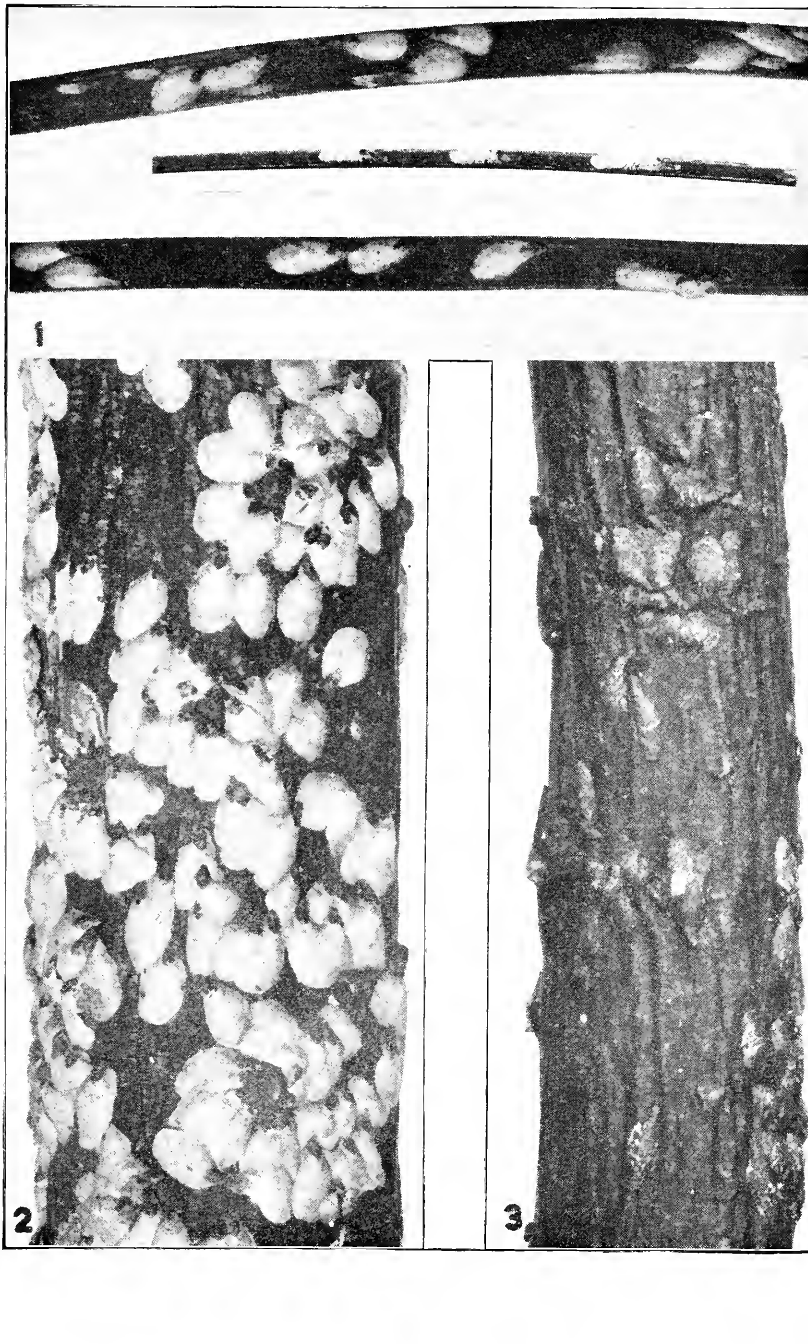
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PLATE L

Fig. 1.—The Honey Locust Scale (*Chionaspis gleditsiae*). Male and female scales intermingled. The small, white scales are the males, while the larger and less distinct ones are the females. Enlarged.

Fig. 2.—The Rose Scale (*Aulacaspis rosae*). The lower twig bears the male scales and the upper one the larger female scales. Enlarged.

Fig. 3.—The Maple Terrapin Scale (*Lecanium nigrofasciatum*). The scale on the larger twig is almost natural size.

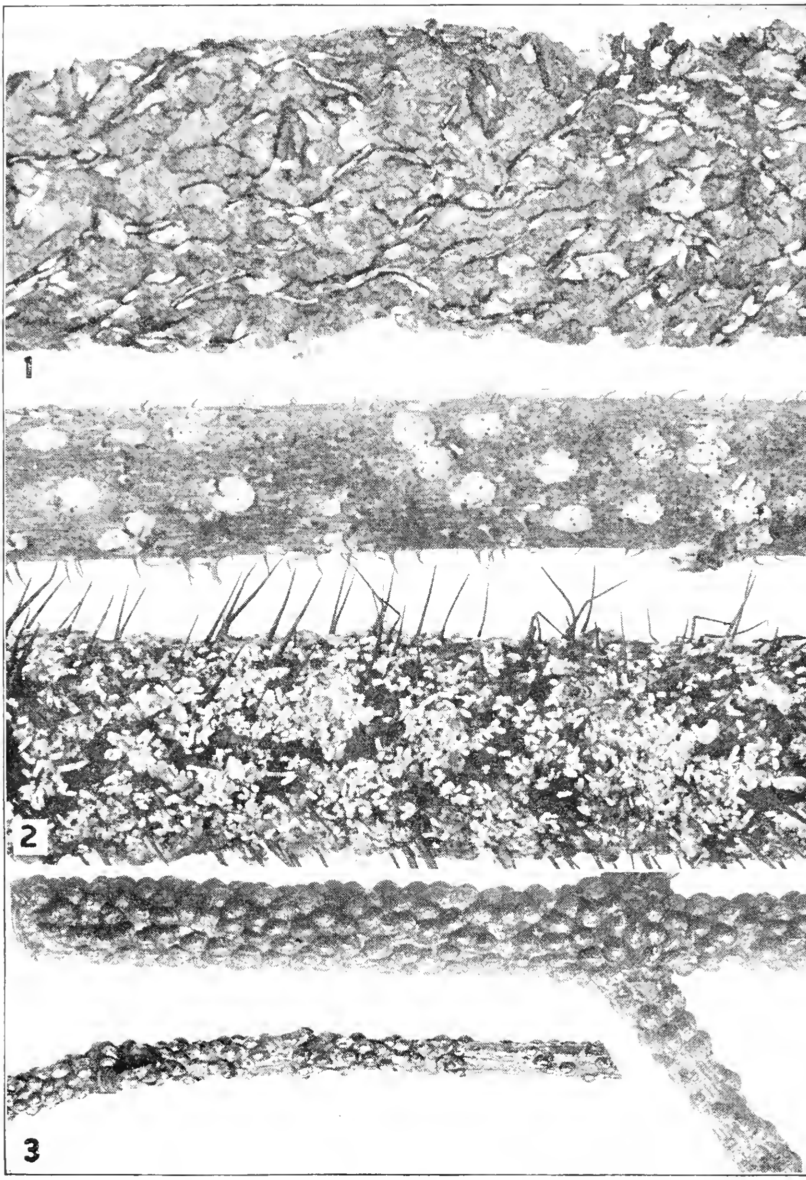
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PLATE LI

THE EUONYMUS SCALE
(*Chionaspis euonymi*)

Fig. 1.—Two infested twigs showing the small white male scales and the larger female scales intermingled.

Fig. 2.—A shrub of *Euonymus europeans*, Cleveland, Ohio, dying from an infestation of euonymus scale.

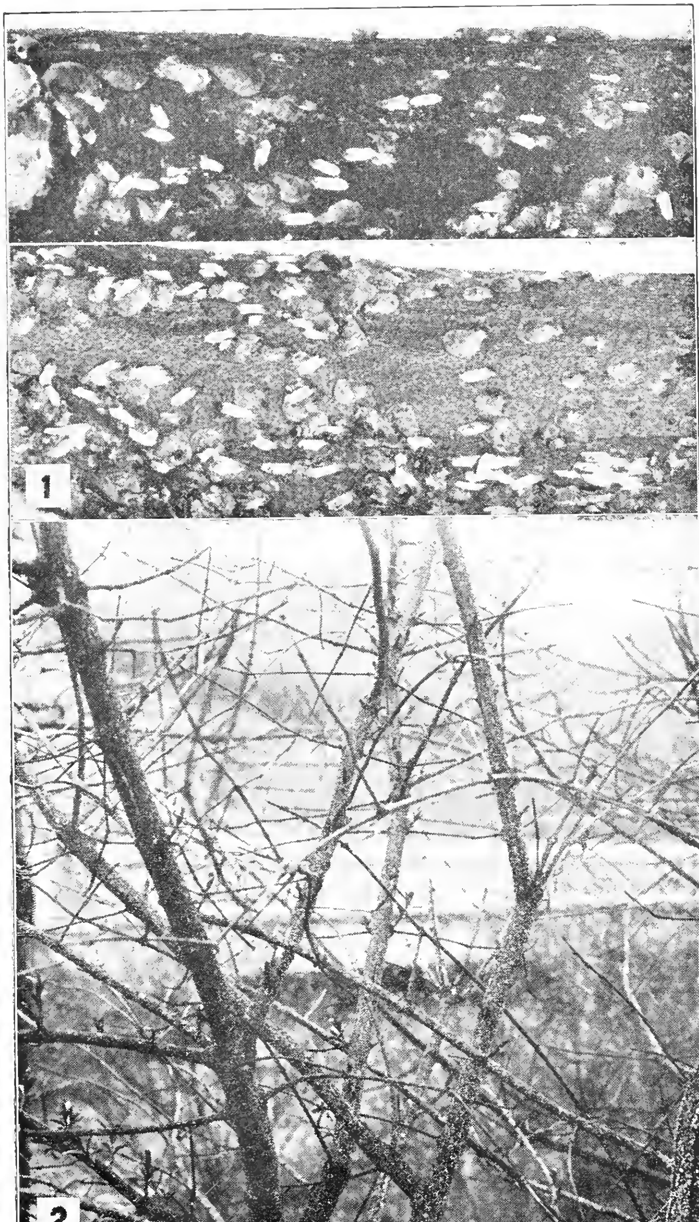

PLATE LII

Fig. 1.—The Cottony Maple Scale (*Pulvinaria vitis*). Adult female with cottony covered egg mass. A little less than natural size.

Fig. 2.—Cottony maple scale. Adult females enlarged. This illustration shows how the mass of eggs covered with loose cottony or waxy threads props up the body of the female insect.

Fig. 3.—Scales and egg masses of the Cottony Maple Leaf Scale (*Pulvinaria acericola*) on the underside of a maple leaf. Enlarged.

Fig. 4.—The migrating young scale insects of the Maple Phenacoccus (*Phenacoccus acericola*) on the trunk of a maple tree. About natural size.

Fig. 5.—The irregular cottony masses which cover the mature insect and eggs of the maple Phenacoccus.

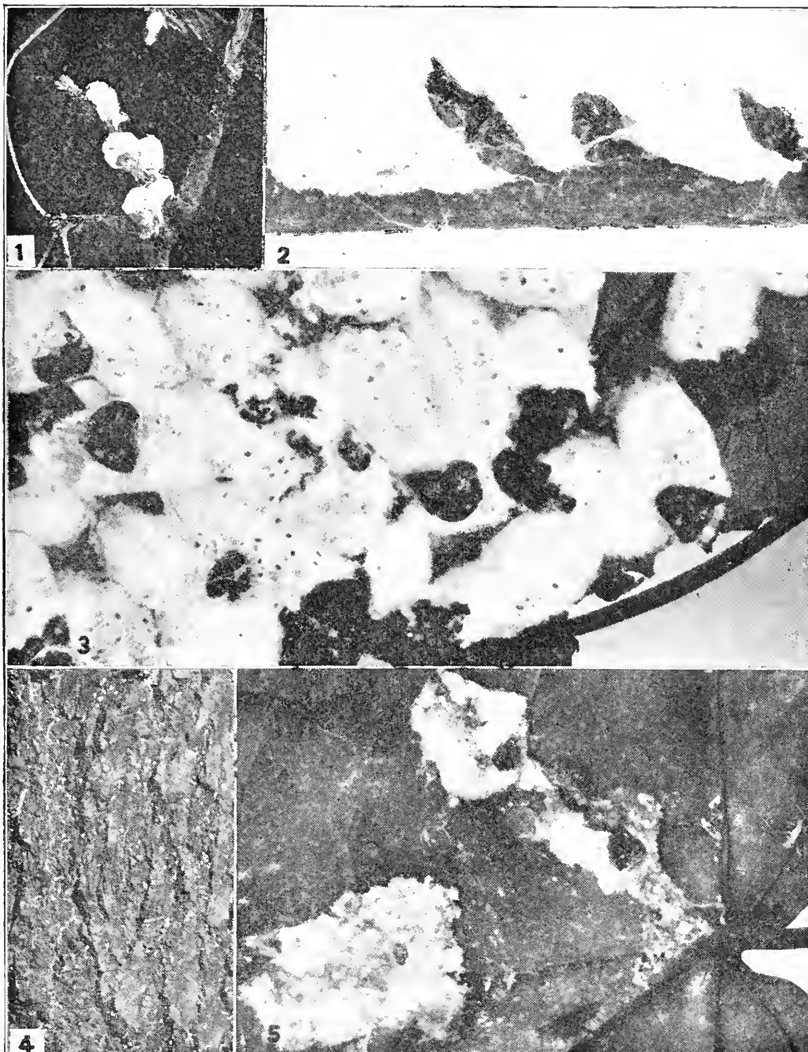
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PLATE LIII

Fig. 1.—The Tulip Tree Lecanium (*Toumeyella liriodendri*). The partly grown winter stage. Enlarged.

Fig. 2.—The mature female scales of the tulip tree lecanium. Slightly reduced.

Fig. 3.—The Magnolia Scale (*Neolecanium cornuparvum.*) Mature female scales enlarged about 2 diameters.

Fig. 4.—A magnolia bush in a dying condition from an attack of the magnolia scale.

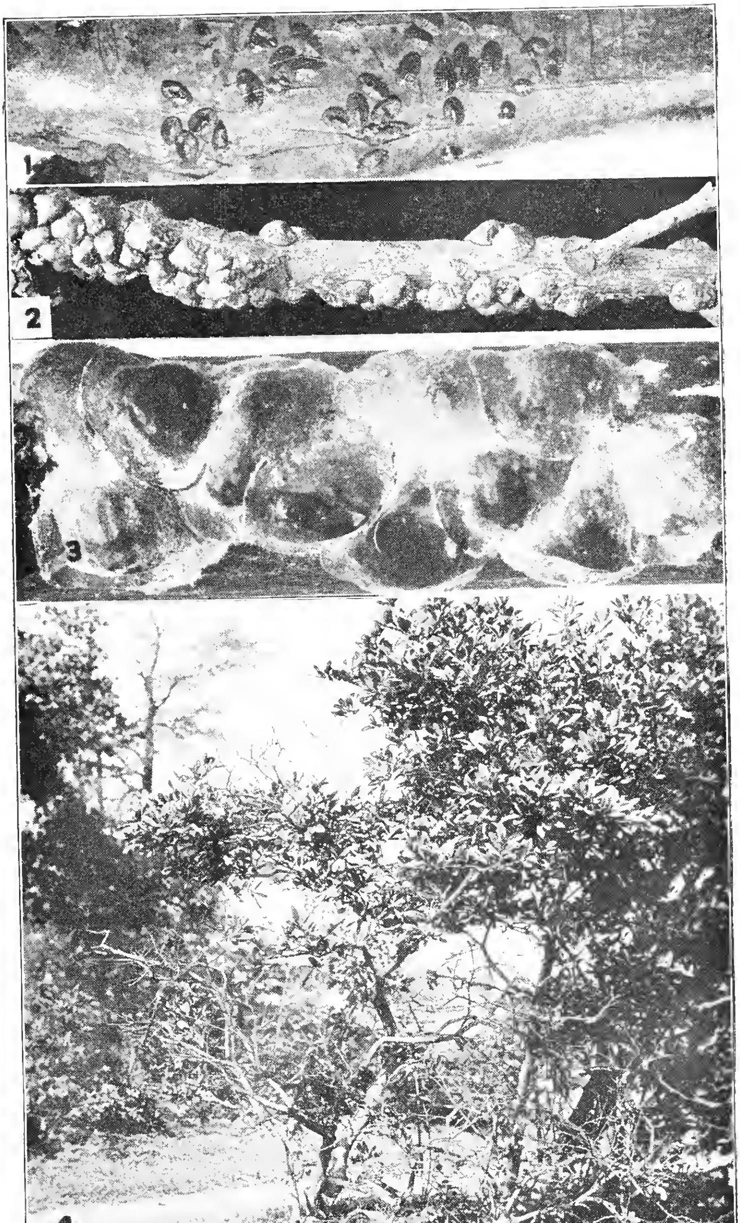
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PLATE LIV

THE EUROPEAN ELM SCALE
(*Gossyparia ulmi*)

Fig. 1.—Adult female insects in position in their protecting waxy nests. Slightly enlarged.

Fig. 2.—The European elm scale in late spring. The louse-like objects are the developing females and the cottony masses are the cocoons of the males.

Fig. 3.—An elm tree, Marietta, Ohio, in a dying condition from an infestation of the European elm scale.

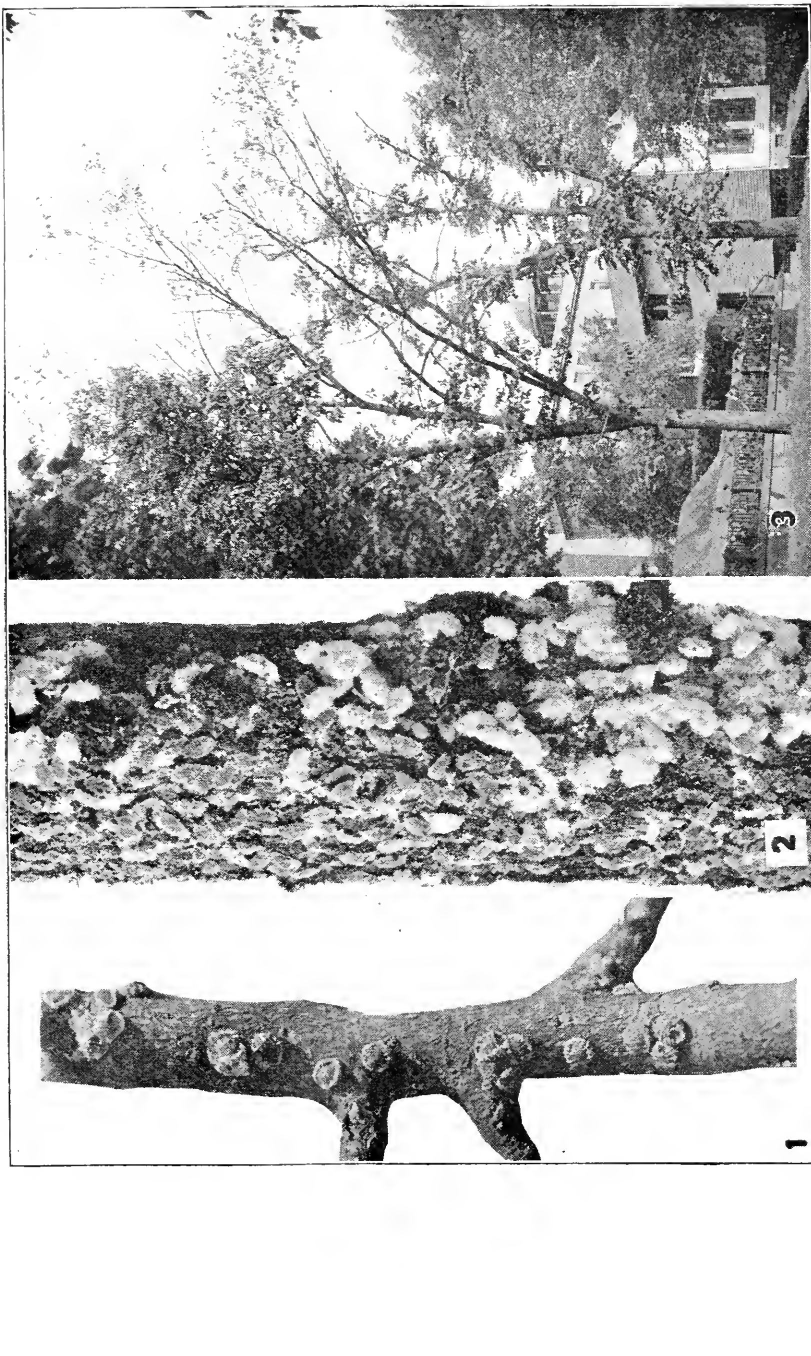

PLATE LV

Fig. 1.—The sooty mold which develops on the foliage of elms badly infested with the European elm scale.

Fig. 2.—The Burr Oak Kermes (*Kermes pubescens*). Slightly reduced.

PLATE LV

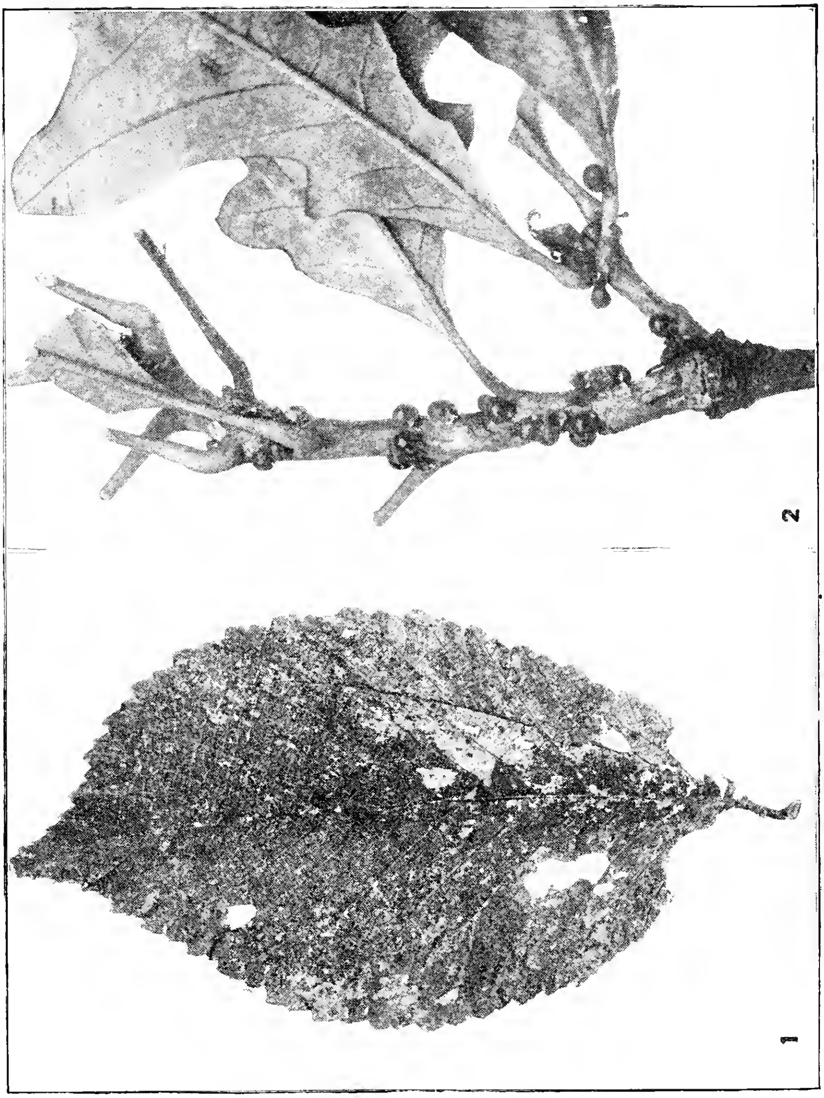

PLATE LVI

THE PIT-MAKING OAK SCALE
(*Asterolecanium variolosum*)

Fig. 1.—Oak twigs severely infested. The twig at the right is seen to be rather deeply pitted where scales have been removed.

Fig. 2.—An English oak, Eden Park, Cincinnati, Ohio, in a dying condition from the work of the pit-making oak scale.

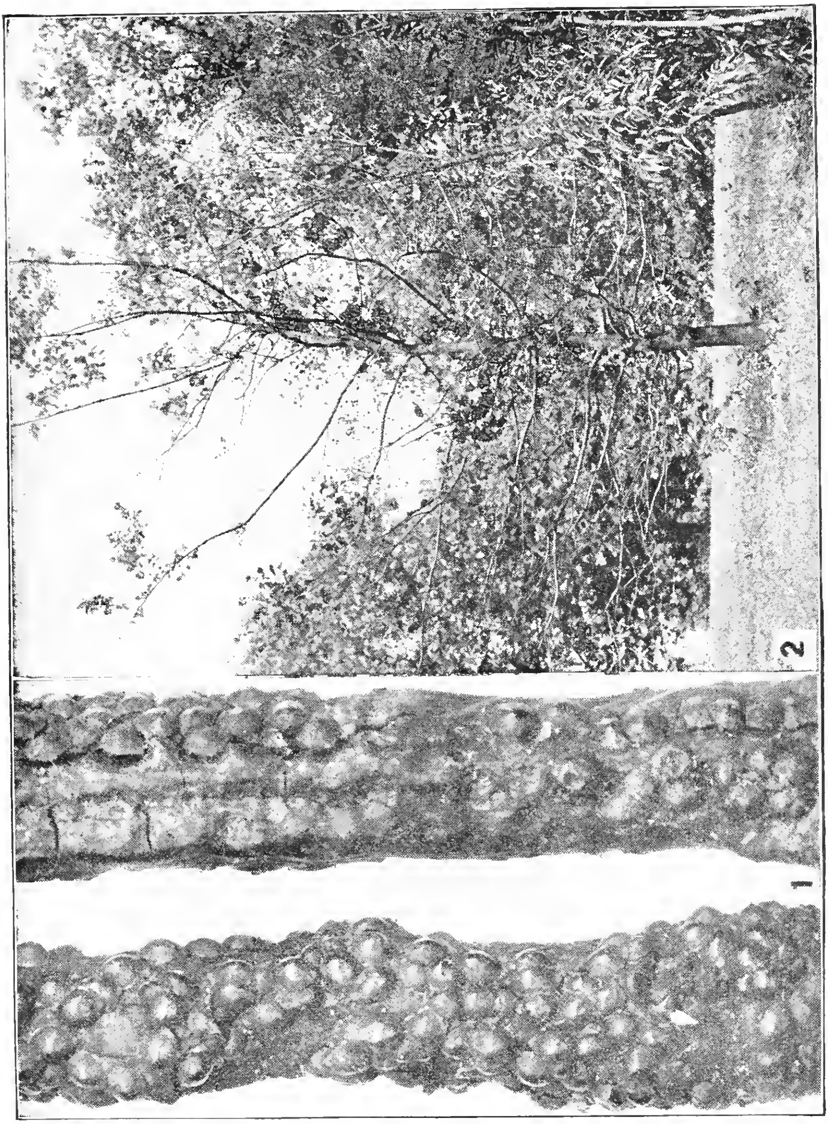
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PLATE LVII

THE COMMON RED SPIDER OR SPIDER MITE
(Tetranychus telarius)

In the five illustrations of this plate the pest is shown in all its stages of development and all are drawings of the same magnification, about 125 diameters.

Fig. 1.—Egg.

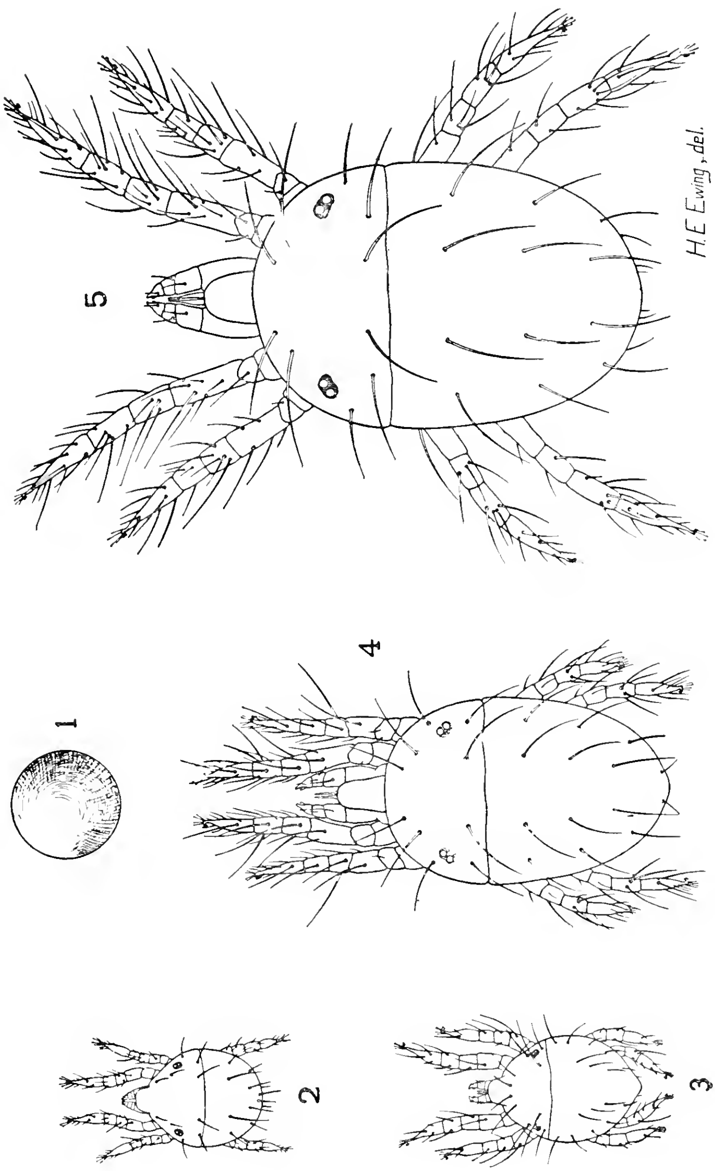
Fig. 2.—Larva.

Fig. 3.—Protonymph, dorsal view.

Fig. 4.—Deutonymph, dorsal view.

Fig. 5.—Adult female, dorsal view.

After Ewing.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H.E Ewing, del.

PLATE LVIII

Fig. 1.—The Pine Bark Aphid (*Chermes pinicorticis*). The trunk of a young white pine showing heavy infestation by this insect. The white, flocculent, waxy covering which the lice secrete from their bodies renders their presence very noticeable.

Fig. 2.—The Cockscomb Gall of the Elm (*Colopha ulmicola*). These galls both in form and color, particularly when the leaf is green and the galls are growing, very closely resemble the comb of a cock. This figure is reduced in size.

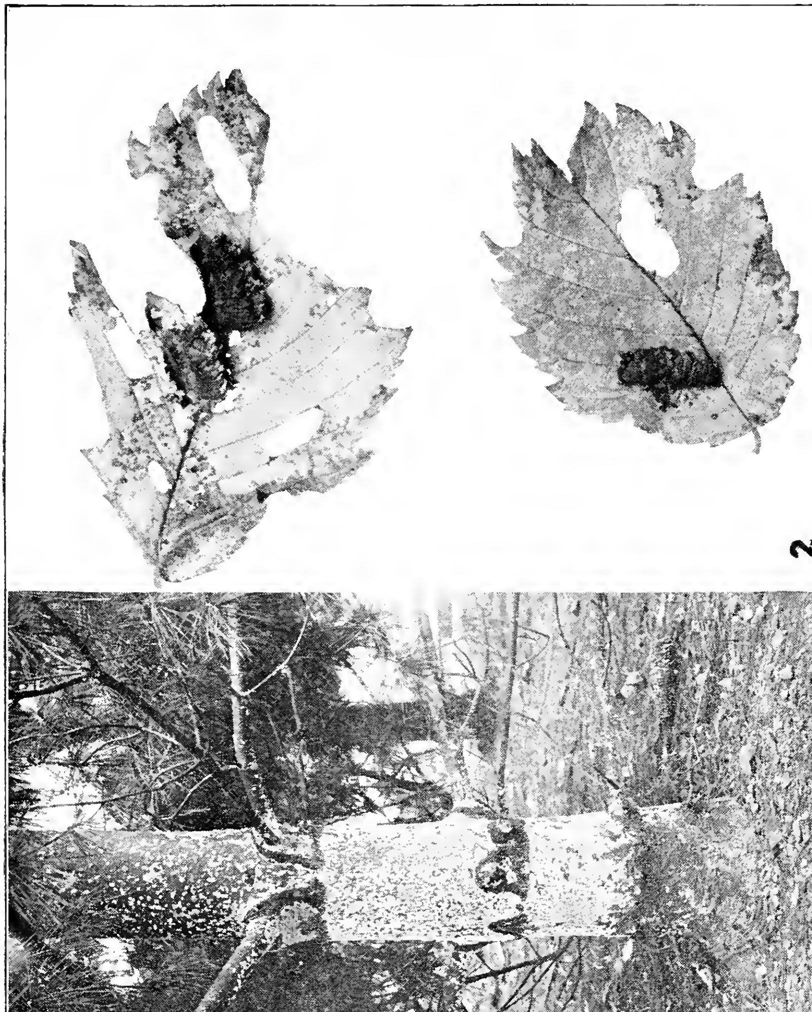
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PLATE LIX

THE CATALPA MIDGE
(Itonida catalpae)

Fig. 1.—Eggs, much enlarged.

Photograph, W. H. Goodwin.

Fig. 2.—Larvae, much enlarged.

Photograph, W. H. Goodwin.

Fig. 3.—Adult, much enlarged.

Photograph, W. H. Goodwin.

Fig. 4.—Feeding spots by larvae on leaves of catalpa. Later the deadened tissue drops out.

Fig. 5.—Typical case of injury to catalpa pods by the larvae of the catalpa midge.

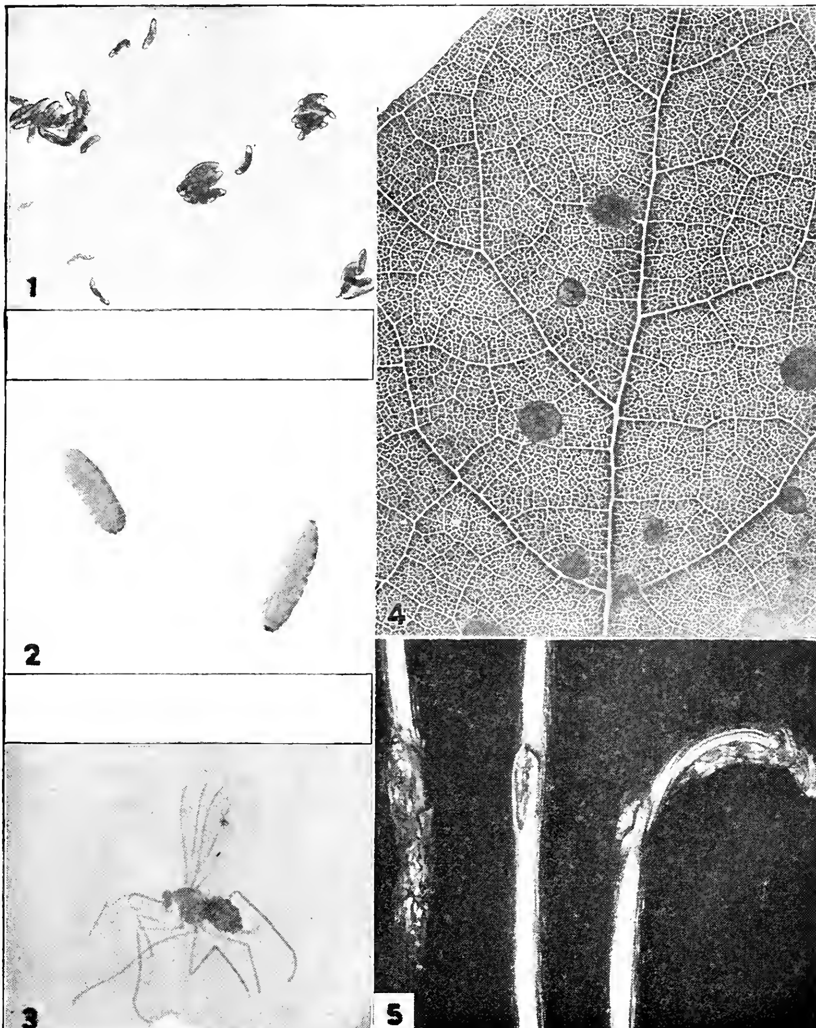

PLATE LX

THE CATALPA MIDGE

(Itonida catalpae)

Fig. 1.—In instances of severe attack by the midge, the myriads of feeding larvae are found clustered along the midribs and veins of the leaves, causing a complete breaking down or wilting. The wilted leaves are seen in this illustration.

Fig. 2.—After the leaves are wilted they turn brown and become greatly distorted.

Fig. 3.—The leaves of the terminal shoot are attacked first and when the injury is sufficiently severe to kill the leaves, the growing shoot also is affected frequently being killed outright as shown in this figure.

Fig. 4.—The successive killing back of the terminal and other principal shoots ultimately results in a bushy, stunted growth, destroying the value of the catalpa for post and pole timber.


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PLATE LXI

THE SYCAMORE LACE BUG
(*Corythuca ciliata*)

Fig. 1a.—The adult enlarged about 20 diameters. Note the lacy appearance of the bug.

After Wade.

Fig. 1b.—Side view of hood and median carina of the adult.

After Wade.

Fig. 2.—Egg. Enlarged abor 25 diameters.

After Wade.

Fig. 3.—The third nymphal instar. Enlarged.

After Wade.

Fig. 4.—The characteristic appearance of a sycamore leaf injured by the sycamore lace bug.

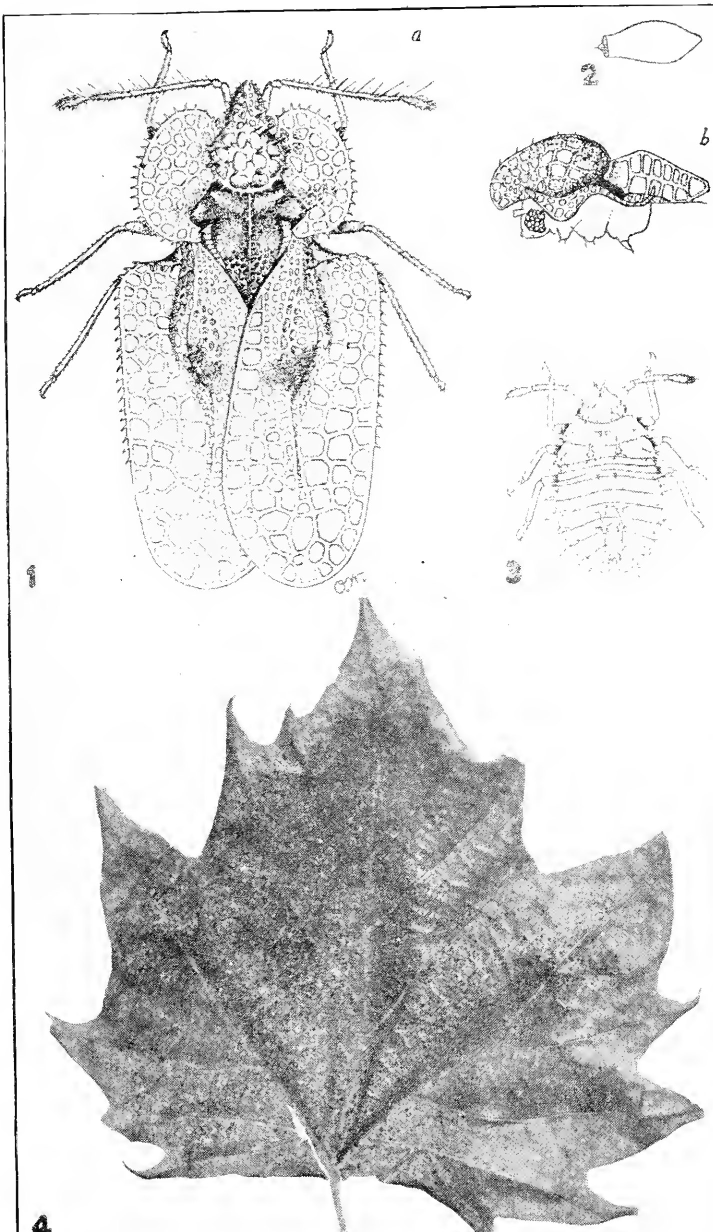
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PLATE XLII

THE LOCUST BORER
(*Cyllene robiniae*)

Fig. 1.—The eggs much enlarged inserted in the crevices of a split limb.

Fig. 2.—The adult beetle. Enlarged about three diameters.

Fig. 3.—Characteristic burrow in the trunk of a young locust tree, showing larva within.

Fig. 4.—A young locust tree broken by wind as a result of the work of the borer.

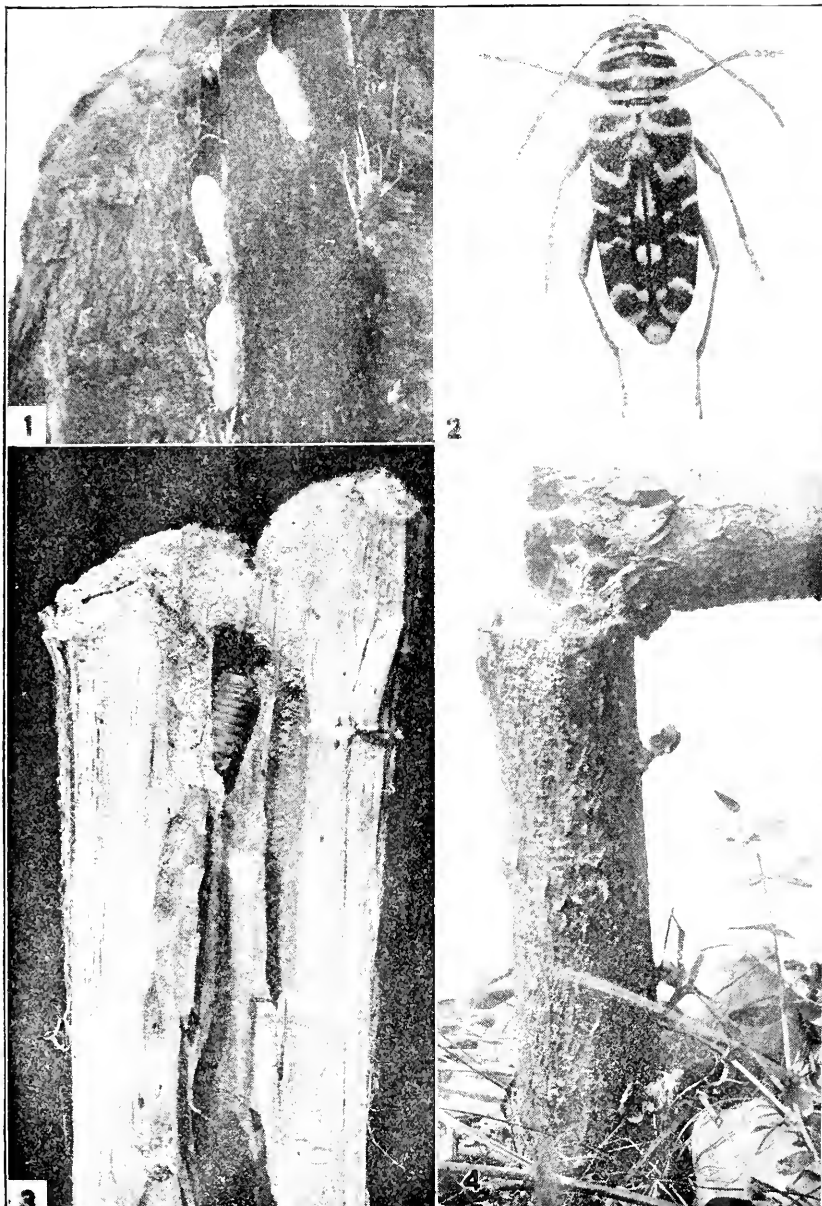
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PLATE LXIII

THE LOCUST BORER
(*Cyllene robiniae*)

Fig. 1.—Adult beetles feeding upon the flower of goldenrod.

Fig. 2.—A typical case of injury to the trunk of a young locust by the larvae of the locust borer.

PLATE LXIII

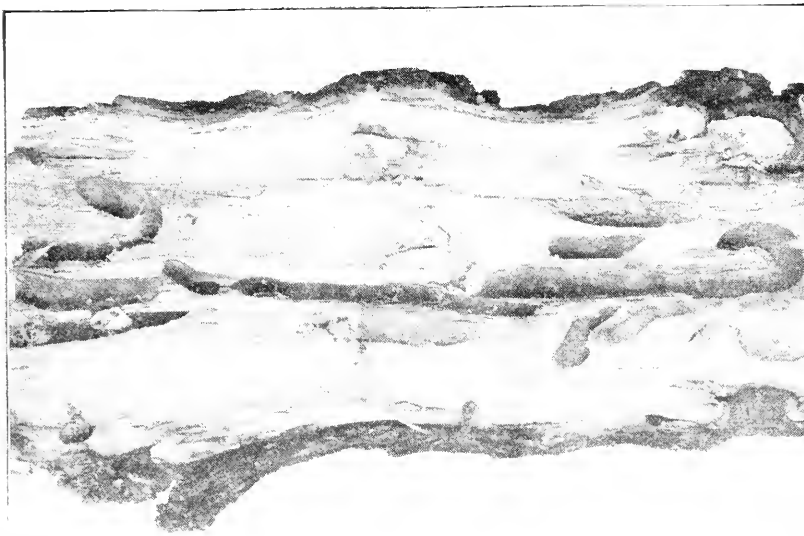

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PLATE LXIV

Fig. 1.—The Locust Twig Borer (*Ecdytolopha insiticiana*). Characteristic injury to locust twigs with a larva exposed in its burrow.

Figs. 2 and 3.—Injury to the trunk of growing poplar by the larvae of the poplar borer, *Saperda calcarata*.

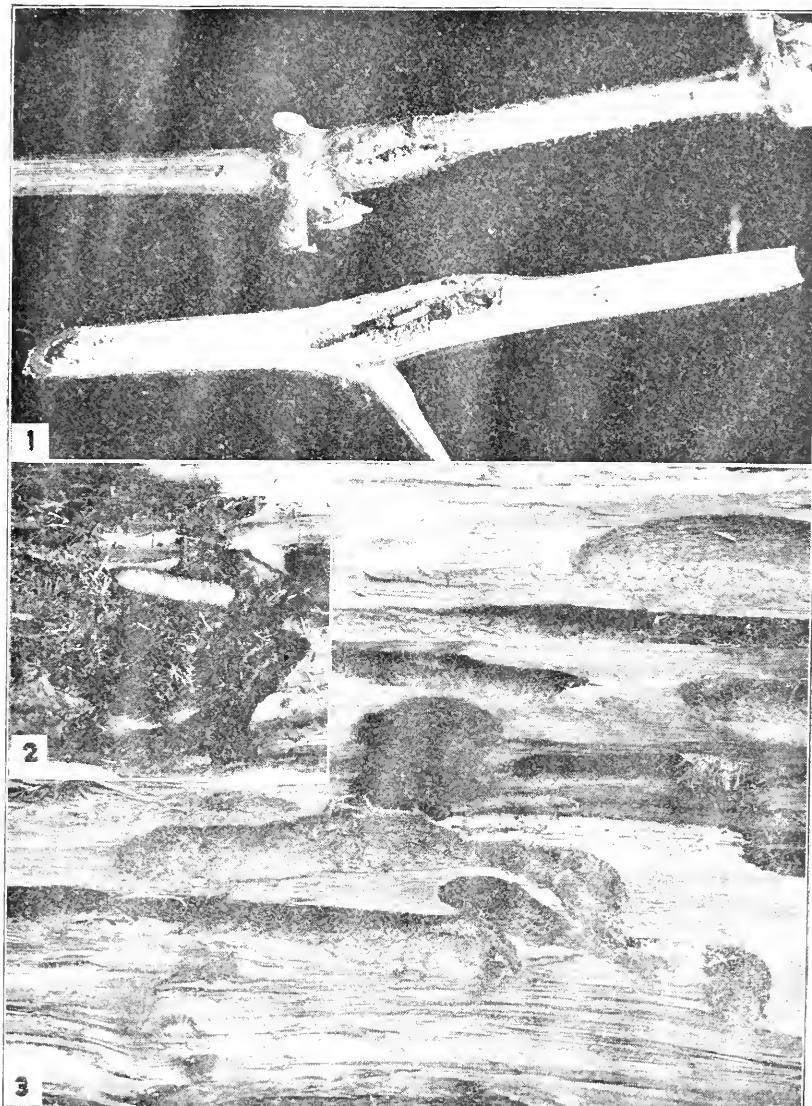

PLATE LXV

THE POPLAR AND WILLOW BORER
(*Cryptorhynchus lapathi*)

Fig. 1.—Adult beetle. Enlarged about eight diameters.
After Matheson.

Fig. 2.—The trunk of a young Carolina poplar, showing characteristic swellings and mutilation due to this beetle.

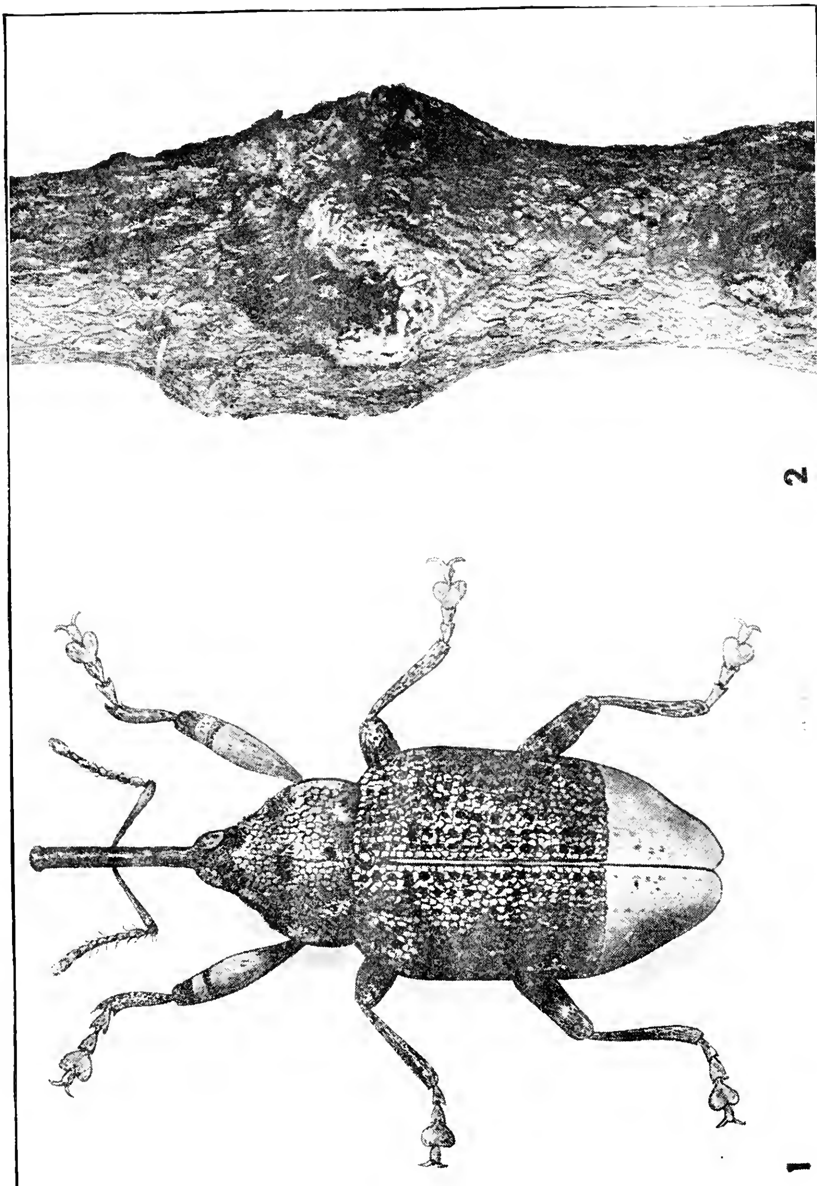
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PLATE LXVI

THE HICKORY BARK BEETLE
(*Scolytus quadrispinosus*)

Fig. 1.—Different stages and galleries in the wood made by the beetle and its larvae.

After Riley.

Fig. 2.—A hickory tree, Akron, Ohio, killed by the hickory bark borer.

PLATE LXVI

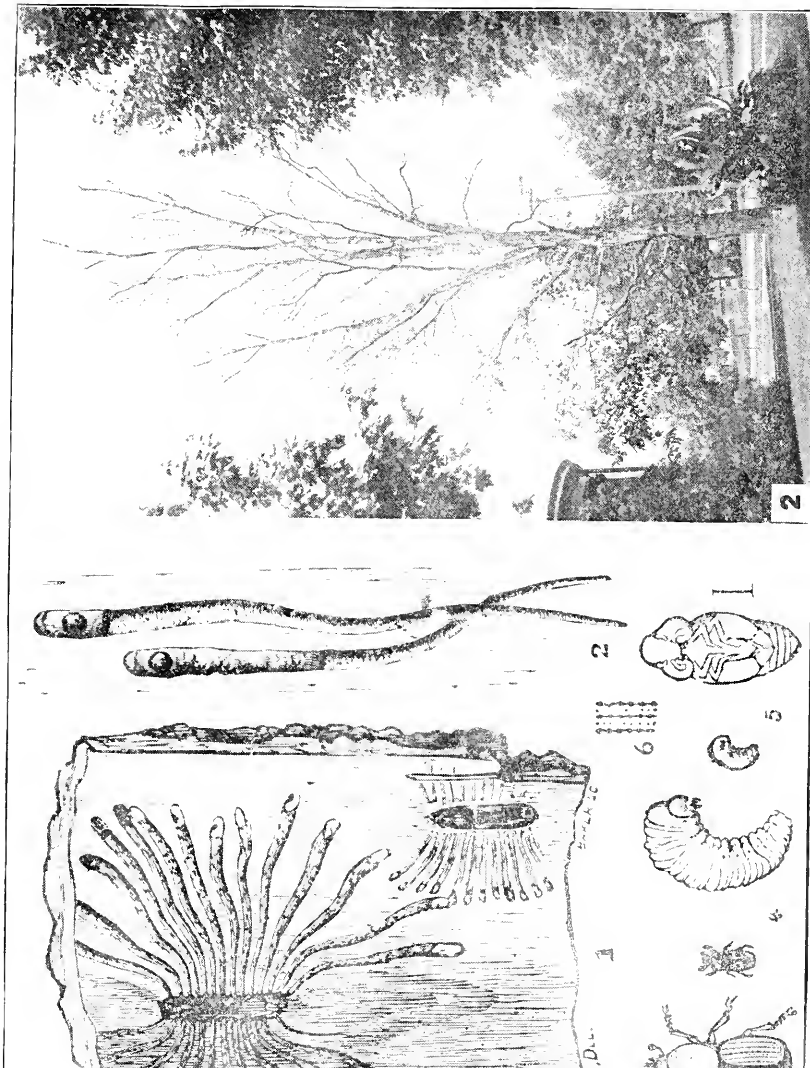

PLATE LXVII

Fig. 1.—The Maple Borer (*Synanthedon acerni*). A branch split open to show the work of the borer and the rot which follows to further weaken the host.

Fig. 2.—The outside appearance of a branch of maple attacked by the maple borer. Note the enlargement of the branch and the killing of the bark, which allows rots to become established.

Fig. 3.—The Carpenter Worm (*Prionoxystus robiniae*). An adult female moth somewhat enlarged.

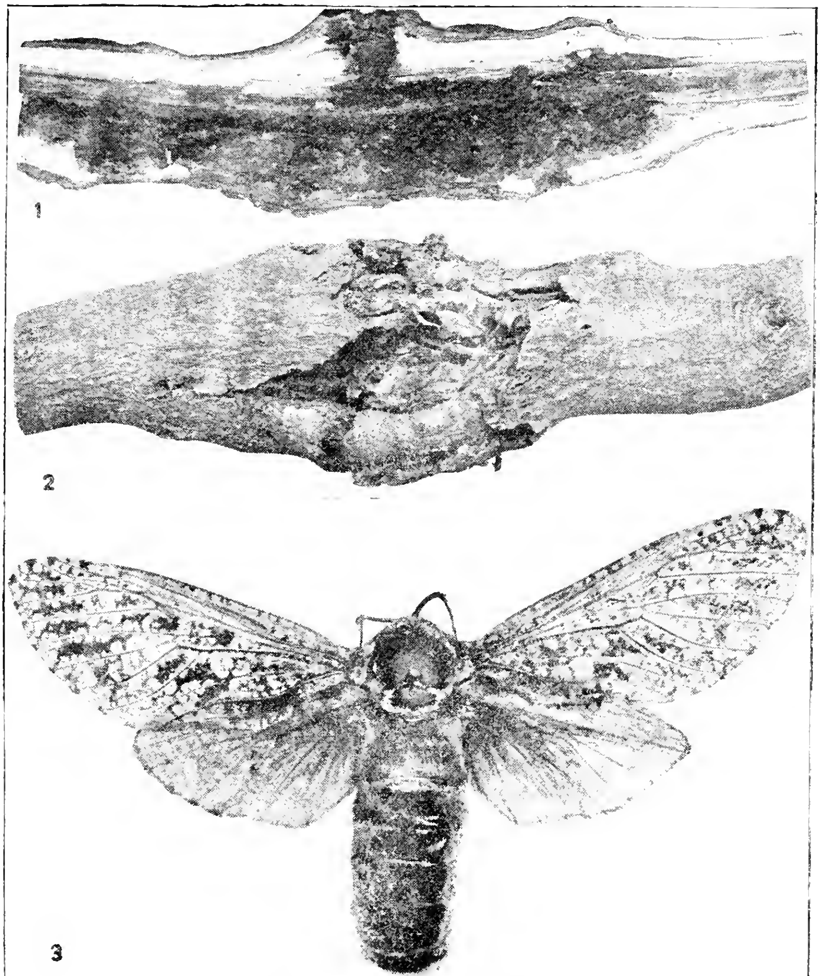
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PLATE LXVIII

THE WHITE PINE WEEVIL
(*Pissodes strobi*)

Fig. 1.—Adult, larva and pupa, much enlarged. The little figure beside the beetle is a little less than natural size.

After Hopkins.

Fig. 2.—A shoot of white pine showing feeding and egg-laying punctures of adult beetles.

Fig. 3.—Shoot of white pine showing galleries of weevil and larvae and pupa within.

Fig. 4.—A shoot of white pine showing exit holes of weevils.

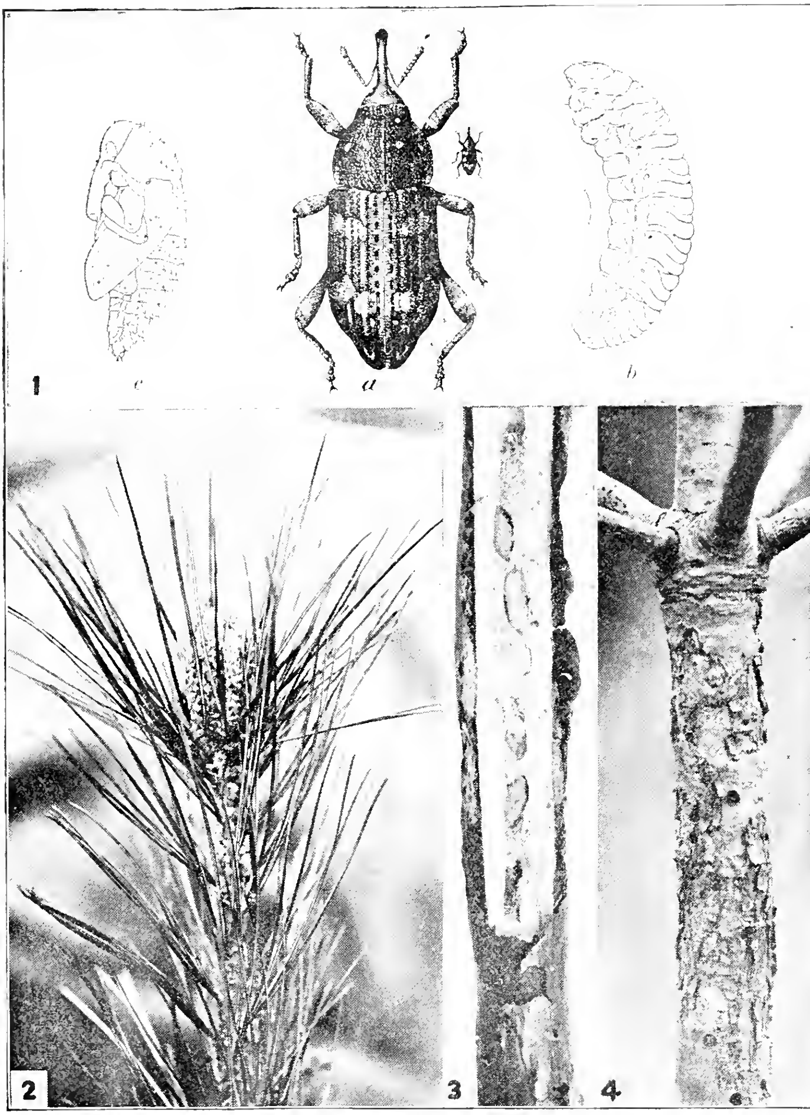
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PLATE LXIX

THE WHITE PINE WEEVIL

(*Pissodes strobi*)

Figs 1 and 2.—Young white pines with the terminal shoot killed by the white pine weevil. Such a condition is disastrous to the future development and symmetry of the tree.

Fig. 3.—A general view of the areas regenerated by white pine seedlings on the slope of Little Mountain, near Mentor, Ohio. On this slope fully 90 percent of the young trees had had the terminal shoot destroyed.

PLATE LXX

Fig. 1.—The Maple and Oak Twig Pruner (*Elaphidion villosum*). a, b and c show the insect in the larval, adult and pupal stages; d and e, the cut ends of a severed twig, and f, the pupa within a gallery in the severed twig.

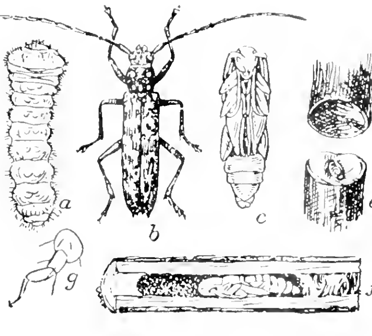
After Chittenden.

Fig. 2.—The Bronze Birch Borer (*Agrilus anxius*). Larva and adult enlarged about three diameters.

After Chittenden.

Fig. 3.—The Pigeon Tremex (*Tremex columba*). Larva, adult and pupa. Slightly enlarged.

After Riley.



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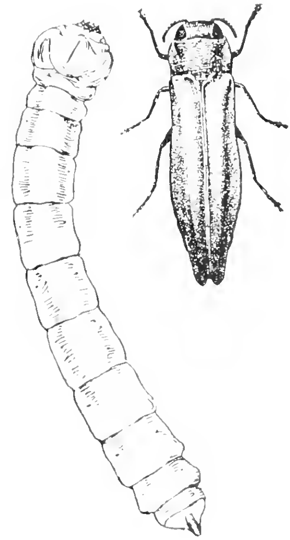

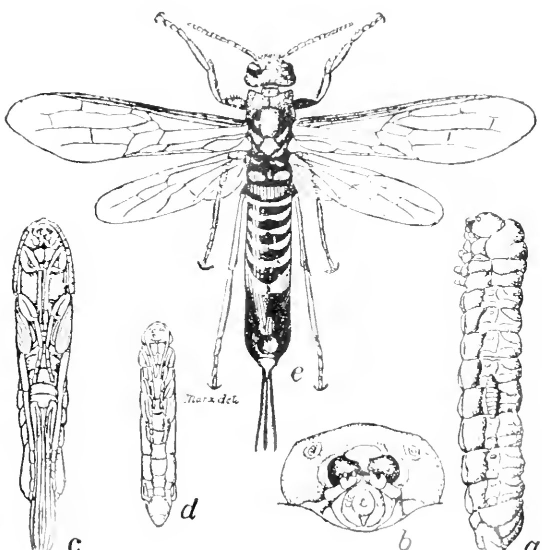

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INDEX

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